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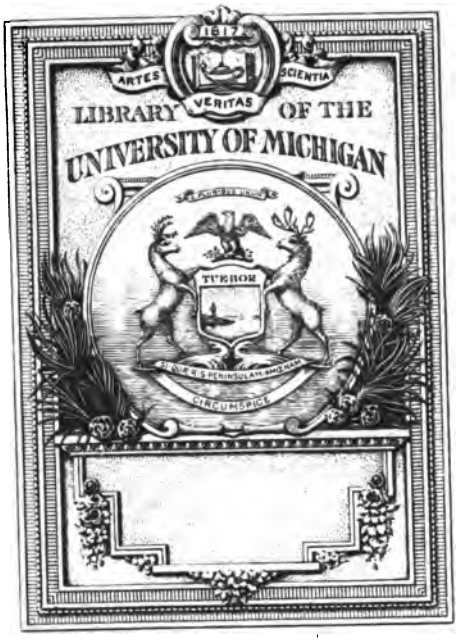
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REPORT *of the*

STATE IRRIGATION COMMISSIONER

TO THE

KANSAS STATE BOARD *of* AGRICULTURE

FOR THE PERIOD

June 16, 1919, to June 30, 1920

KANSAS STATE PRINTING PLANT
IMRI ZUMWALT, STATE PRINTER
TOPEKA. 1920
8-5335

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General 8

LETTER OF TRANSMITTAL.

To the Kansas State Board of Agriculture:

I have the honor to transmit herewith a report of the work and finances of the Division of Irrigation from the time of my assuming the duties of my office, on June 16, 1919, to June 30, 1920, with recommendations relating to irrigation activities.

Very respectfully,

GEO. S. KNAPP,
State Irrigation Commissioner.

REPORT OF THE COMMISSIONER.

CHAPTER I.

WORK AND FINANCES OF THE DEPARTMENT.

DISCUSSION OF NEW IRRIGATION LAW.

The twenty-first biennial session of the legislature, in 1919, repealed the acts of 1915 and 1917 which provided for the construction of irrigation pumping plants in counties west of the 100th meridian for experimental and demonstrational purposes. In the place of these acts it created a Division of Irrigation in the State Board of Agriculture, to be under the control of an irrigation commissioner appointed by the Board of Agriculture. The duties of the irrigation commissioner, as set forth in the law, are:

"(1) To gather data, information and statistics from the existing irrigation plants in the state concerning the water supply and methods of securing the same and the methods employed in applying water to crops, and he shall tabulate and preserve in available form such information and shall publish and distribute the same from time to time; (2) to visit the site of any proposed irrigation plant in the state, upon the request of any citizen of the state, and advise as to the feasibility of installing such plant, and furnish plans and specifications therefor upon request, such visits to be made only when his actual expenses therefor are guaranteed by the person requesting such visit; (3) to operate by lease, under competitive bids, all existing irrigation plants now owned by the state of Kansas and installed by the Board of Irrigation, Survey, Experiment and Demonstration, or the state irrigation commissioner, until such time as he shall have determined the feasibility of irrigation under conditions existing at each of such plants, and all proceeds from the operation of any such plants shall be paid into and become a part of the funds herein provided, for the payment of the expenses of conducting such department; (4) to immediately take charge of all property of every kind and nature now belonging to the state of Kansas and heretofore purchased or otherwise acquired by the Board of Irrigation, Survey, Experiment and Demonstration, and the state irrigation commissioner, and shall have authority to sell and dispose of any such property, not including real estate and not necessary for carrying out the work of such department; (5) to make quarterly reports to the State Board of Agriculture, including itemized accounts of all receipts and expenditures of such department."

The passage of this act marked a change on the part of the state in its efforts to develop the water resources of Kansas for purposes of irrigation. By this action it discontinued the construction of irrigation pumping plants for purposes of experiment and demonstration. This was prompted, no doubt, by the fact that such plants have proven very expensive and have been productive of but little information regarding either the water resources of the state or the feasibility of pumping for irrigation. Usually these plants have been installed in localities where

the depth to water was great and where the possibilities of securing water were remote, and at these locations neither the density of the population nor general economic conditions were such that any extensive irrigation development could be expected. Instead of limiting itself in its scope to what information it might obtain from these plants, which necessarily were few in number and often unfavorably located, the state has undertaken to work out its irrigation problems and development on broader lines by gathering information from the hundreds of irrigation plants already in operation in various parts of the state, publishing this information for the benefit of those interested in irrigation, and rendering sufficient assistance to those contemplating the installation of a plant, so that failures and unsatisfactory installations, which have been common, especially in new localities, are unnecessary. Properly administered, this law should do more to promote the development of irrigation enterprises than previous legislation has done.

The irrigation commissioner was appointed on May 29, 1919, and assumed the duties of his office on June 15.

APPROPRIATIONS AND EXPENDITURES.

To carry on the work of the department the following sums were appropriated:

For the fiscal year ending June 30, 1919	$2,000
For the fiscal year ending June 30, 1920	10,500
For the fiscal year ending June 30, 1921	10,500

These appropriations were made in a lump sum for the expenses of the department, but besides fixing the salary of the commissioner at $3,000 per annum, the law limited him to the expenditure of $2,000 per annum for clerical help, and authorized him to use a sum not exceeding $2,500 per year for expenses incurred in cases against the Colorado ditches to prevent the diversion of water from the Arkansas river.

The expenditures made during fiscal years ending June 30, 1919 and 1920, respectively, are:

	1919.	1920.
Salary irrigation commissioner	$125.00	$3,000.00
Clerical help	.....	324.00
Kansas-Colorado water controversy	.....	943.59
Traveling expenses, supplies and help	60.23	2,869.67
Totals	$185.23	$7,155.26

ACCOUNTS OF FORMER COMMISSIONER.

When the above-mentioned acts of 1915 and 1917 were repealed the funds available for that work reverted to the general-revenue fund. The irrigation commissioner, under whose administration the work authorized by these acts was done, failed to complete the business of his department before such funds were no longer available. Various small bills had not been paid and a number of accounts due the state from the sale of seed, water, etc., had not been collected. Through the efforts of this department the 1920 special session of the legislature passed a bill which made funds available and authorized the present commissioner to pay such

past-due accounts and collect any amounts due the state from the transactions of the former commissioner. Pursuant to this the following individuals or firms were paid in the amounts indicated:

Union Pacific Railroad Co.	$8.11
Leonard Rewerts, Leoti	8.70
Claude Champion, Dighton	90.00
Scott City Furniture Co., Scott City	9.00
Layne & Bowler Co., Memphis, Tenn.	48.00
Western Times, Sharon Springs	5.00
J. W. Lough, Scott City	275.10
Standard Oil Co.	61.42
Fitzgerald Lumber Co., Colby	35.79
Total	$541.31

Collections were made from the following:

J. L. Sharpe	$145.00
B. M. Norris	20.00
J. W. Lough	22.75
J. W. Lough	25.76
Ellis Short	119.00
W. D. Luke	25.00
J. W. Lough	154.85
Total	$512.36

WORK OF THE DEPARTMENT.

Since its establishment this department has done engineering work and furnished plans for irrigation projects to twenty-five farmers. Seventeen of these projects consisted of topographic surveys aggregating over 1,700 acres. Ditch systems for the distribution of water were planned for this land and maps made showing the topography of the land and a plan of the ditch system. One large irrigation dam was designed and profile surveys made for two other dams. Plans were also made for three small earthen reservoirs for use in connection with irrigation pumping plants. In addition to this, the feasibility of a larger irrigation project was investigated and a report made to the interested parties.

A great many farms have been visited by the irrigation commissioner for the purpose of advising with the proprietors concerning irrigation plants which they propose to install; plants which they already have, the operation of which has been unsatisfactory, or plants which they wish to change, remodel or enlarge. These visits have not often been made the subject of a written report, but much valuable assistance has been rendered in this manner.

Hundreds of letters have been received asking for information regarding the cost of irrigation plants, the water supply in various localities, and the feasibility of irrigation in such localities. In connection with these inquiries it is worthy of note that the greatest number do not come from those counties having the largest irrigated acreage. Almost 80 per cent of the present irrigated land is in three western counties, but less than 8 per cent of the inquiries received have come from those counties. The reason for this may be partly explained by assuming that people living in these counties, where many of the farmers are irrigating, have a

ready source of information and do not need to write to the irrigation commissioner for it. Be that as it may, the most noteworthy feature of it is the fact that the interest in irrigation is general and widespread. Legislatures in the past have been wont to act on the assumption that irrigation was applicable only to about the western third of the state. Many of our laws relating to the appropriation of water for irrigation contain such clauses as these: "In all that portion of the state of Kansas situated west of the ninety-ninth meridian, all natural waters, whether standing or running, and whether surface or subterranean, shall be devoted, first, to purposes of irrigation in aid of agriculture," or, "All waters flowing in subterranean channels and courses, or flowing or standing in subterranean sheets or lakes south of township 18 and west of the ninety-ninth meridian, shall belong and be appurtenant to the lands under which they flow or stand, and shall be devoted, first, to the irrigating of such lands." Notwithstanding this, nearly 50 per cent of the inquiries made to the irrigation commissioner have come from east of the ninety-ninth meridian. The inquiries received have come generally from all parts of the state, irrespective of the boundaries of supposedly semiarid or more humid sections. They show an increasing and more general interest in irrigation, prompted, no doubt, either by an increasing need or a better appreciation of the value of irrigation.

If there is an increasing need for irrigation the cause of it cannot be found in a decreasing rainfall or changing climatic conditions, for in the past two years Kansas has produced crops surpassing almost any previous year in value. The publication of information regarding the pumping of water for irrigation has beyond doubt created some interest. The increasing value of land and cost of labor is also doing much to stimulate an interest in irrigation. The farmer, having to make a larger investment in his crop, can take less risk of losing it by drought. If he can make his harvests more certain or his yields greater by irrigating he is interested in knowing how. The idea that the practice of irrigation would reflect on natural advantages of the country, or would decrease its value in the eyes of a home seeker, is giving away to a better appreciation of the value of irrigation. Communities which used to resent the implication that irrigation would be profitable there are beginning to look upon the possibility of irrigation as a real asset, and land which has within its reach a water supply sufficient for irrigation purposes is becoming the most valuable land in the state.

The irrigated acreage in the older districts is being constantly increased by the addition of more pumping plants, but an analysis of the inquiries received shows that the greatest interest in irrigation development is outside of the older districts. Many localities in which little or no irrigating has been done, but which seem to have water supplies that offer opportunities for irrigation development, are becoming greatly interested in irrigation. The services of the irrigation commissioner are in the greatest demand in these newer districts and it is in them that the greatest service can be rendered. With the proper encouragement some of these localities have the possibility of developing into the most valuable irrigated districts of the state.

Since the legislature authorized the expenditure of $2,500 per year to protect the rights and interests of the citizens of Kansas in their controversy with Colorado over the diversion of the waters of the Arkansas river in that state, the irrigation commissioner has made a somewhat exhaustive study of the water controversy. A report of this with his recommendations in the matter is made the subject of a subsequent chapter.

PUBLICATION OF INFORMATION.

A description of some of the most common types of irrigation pumping plants in Kansas, with estimated costs of construction, was published by the irrigation commissioner as the June quarterly report of the Board of Agriculture. Letters for information usually contain a multitude of questions, of which the following are examples: What kind of a plant is best suited to my locality? What kind of pump should I use? How large should it be? How many horsepower will it need to run it? What will it cost to install such a plant? To answer these inquiries in detail frequently requires a two-page letter. This publication answers such questions more fully than a letter can. It contains a description of five of the most commonly used types of pumping plants and explains the conditions for which each is particularly suited. It contains tables showing what size of the various types of pumps is required for any desired quantity of water, the number of horsepower needed to pump this water from various depths, and the estimated cost of such plants where either electricity or an engine is used for power, or where the plant is put in without power, as is sometimes the case where a farmer wishes to use his tractor for power. This is the only publication to be had dealing with this important phase of irrigation pumping, and its publication has been the subject of much favorable comment from those interested in irrigation pumping plants.

The irrigation commissioner now has in course of preparation a bulletin showing the effect of different quantities of irrigation upon the yields of a number of staple crops. This bulletin will present the results of five years' experiments at the Garden City Experiment Station, during which time the commissioner was superintendent of that station.

CHAPTER II.

STATE IRRIGATION PLANTS.

Of the irrigation plants installed by the Board of Irrigation, Survey, Experiment and Demonstration, and the former irrigation commissioner, three were still in the possession of the state at the time the present commissioner assumed his duties. These plants are located at Modoc in Scott county, Selkirk in Wichita county, and Weskan in Wallace county.

DESCRIPTION OF PLANTS.

The irrigation plant at Modoc consists of an 80-horsepower Charter engine, an American turbine centrifugal pump, and three wells connected to the pump by a suction pipe laid through tunnels between the wells just above the water table. The wells have pits about five feet in diameter dug down to water, which is about 90 feet. Fourteen-inch galvanized well casing is used through the water-bearing material, which is about 40 feet thick. The capacity of this plant is about 1,000 gallons per minute.

There are forty acres of land in this project, and improvements, exclusive of the pumping plant, consist of two small houses about 14 by 20 feet each, a shed 16 by 38 feet, and a well and windmill for domestic purposes.

The Selkirk plant has a 70-horsepower Charter engine, an American turbine centrifugal pump, and seven wells connected to the pump by a suction pipe laid through tunnels between the wells. These wells, like those at Modoc, are dug down to water and have perforated well casing sunk through the water-bearing stratum. It is 108 feet to water and there is about 60 feet of water in the wells. This plant in its present condition furnishes about 550 gallons of water per minute.

The farm consists of forty acres of land, which is well fenced. The only improvements on this project, outside of the irrigation pumping plant, are two camp shacks 16 by 20 feet and 10 by 30 feet, respectively, a shed 16 by 18 feet, and a well and windmill for domestic use.

The irrigation plant at Weskan has a 100-horsepower, two-cylinder, vertical Fairbanks-Morse engine, a Layne-Bowler eight-stage deep-well turbine pump, and a well 26 inches in diameter and 240 feet deep. The depth to water at this plant is 108 feet.

There are 160 acres in this farm, 80 acres of which are under cultivation and 80 acres still in grass. The improvements consist of a fairly good four-room house 26 by 26 feet, a bunk house 12 by 28 feet, a good barn 20 by 28 feet and high enough for a good hay loft, several small buildings, and a well and windmill for domestic purposes.

There is considerable agricultural machinery, such as plows, harrows, mowers, etc., and some small tools at these plants.

COST OF PLANTS.

The cost of the wells, machinery, equipment and improvements, as near as could be determined by the state accountant and the present

commissioner, is $31,965, divided between the three plants as follows: At Modoc, $9,267; at Selkirk, $9,508; at Weskan, $13,190. These costs were obtained by taking the cost of such items as engines, pumps, equipment, etc., from the state vouchers, and where costs could not be obtained—as, for example, the cost of a building—an estimate was made of its value or probable cost. They do not represent the total cost of these projects, for it was impossible to obtain many of the labor items, nor do they in all cases represent the value of the property at this time, since the machinery has depreciated in value during its use. All of these plants cost considerably more than the amounts given above. This is especially true at the Weskan plant, where a well 240 feet deep and costing not less than $2,400 had to be abandoned because a suitable water supply was not obtained and where two pumps were discarded because they were unsuitable for the work.

OPERATION UNDER PRESENT LAW.

The present law requires that all existing irrigation plants owned by the state of Kansas and under the control of the irrigation commissioner shall be operated by lease. In accordance with this provision the former commissioner leased them to farmers in the spring of 1919 before the present commissioner was appointed. The same farmers leased them again for the season of 1920.

This method of operating the farms has cost the state very little, but it has not resulted in any information of value regarding the feasibility of irrigation under conditions existing at these plants, and that was the object for which they were installed. The experience of the past two seasons has shown that it is impossible to get farmers to assume the necessary expense to operate these plants and carry on experiments the purpose of which is to determine whether or not irrigation can be profitably practiced under such conditions. It has convinced the irrigation commissioner that to continue to operate these farms by lease is merely a waste of time, and that the state should either provide the necessary funds to operate them as experiment and demonstration farms, or abandon the projects entirely and authorize the sale of the property.

FUTURE OPERATION OF PLANTS.

After a careful study of the situation the irrigation commissioner wishes to recommend that the projects at Modoc and Selkirk be abandoned and the property sold, and that the one at Weskan be operated by the state as an irrigation demonstration farm until such time as the desired information on the cost of pumping at this plant and the value of irrigation water can be secured.

There is not enough land at either the Modoc or Selkirk plants to make an economically sized farm, nor are the buildings there sufficient for a resident farmer and the horses and machinery necessary to conduct the farm operations. Practically the same equipment is required for forty acres as for farms having a larger acreage. The Modoc plant is so close to the large acreage already irrigated by similar methods in Scott county that further experimentation there does not seem essential.

The Selkirk plant is farther removed from the pumping districts, but in addition to the fact that the farm has no buildings, the irrigation

plant would require the expenditure of considerable money to put it in shape for efficient operation. The well pits were not walled up when the plant was constructed. Earth from the walls of these pits is constantly caving off and falling into the wells below. In the construction of these wells eight feet of dry sand was encountered just above the water table. On account of the difficulty of making a tunnel through this sand for the suction pipe, the pipe was laid above the sand and about eight feet above the water table. Because of this and the fact that it was necessary to set the pump several feet above the suction pipe, it is impossible to draw the water down in the wells more than nine or ten feet below the normal water level. This draw-down is not sufficient to develop the economical capacity of the wells, and they do not yield enough water with this draw-down to allow the pump to be operated at its most economical capacity. Some information on the cost of pumping water, but more particularly concerning crop-producing power of water, in this locality might be useful. The country adjacent to this plant, however, does not have a plentiful supply of water, and the depth is uniformly great. Neither the price of land nor the density of population are such as to indicate that any real irrigation development can be expected there, and it is doubtful if the necessary expense to carry on irrigation demonstrations to encourage irrigation on this sparsely settled high land would be justified as long as the larger part of the five million acres of shallow-water land in the state is not under irrigation.

The Weskan plant is of more interest in that not only does it pump from the greatest depth or have the greatest lift of any irrigation pumping plant in the state, but it is quite removed from the larger centers of irrigated agriculture. Some data could be secured through the operation of this plant which could not be obtained otherwise. The value of the data is such that it might warrant continuing the operation of this plant even if the other two are abandoned.

The operation of this plant would not be justified by the value of the information on the cost of pumping from a deep well if that were the only consideration. Pumping water is a mechanical operation, the cost of which depends upon the efficiency of the machinery used, and varies directly with the depth from which it is necessary to lift the water, but is unaffected by climatic conditions or geographical locations, except as the latter may affect the cost of power. Data on pumping secured in one locality, when reduced to a "cost per foot of lift" basis, will apply to any locality where the same type of well and machinery is used and a proper correction made for any difference in cost of power. At the Experiment Station at Garden City the state has an irrigation pumping plant, the well and pump of which are of the same type as those at Weskan. Some of the most reliable and valuable data obtainable in the state are being secured from this plant. At the present time it is necessary to depend on this plant for most of our data on pumping from deep wells. Comparative data on the operation of these two plants would undoubtedly be valuable, but that is not the chief value of continuing the operation of the Weskan plant.

The feasibility of irrigation depends not alone on the cost of pumping the water, but also on the value of the crops which the water will pro-

duce as compared with the value of crops which can be raised in the same locality without irrigation. Conditions influencing crop production are different in Wallace county from those in Finney county. At Weskan the rainfall is less than at Garden City, the humidity is greater, the altitude is higher, and the frost-free period is shorter. These factors all affect crop yields. Varieties of crops which have proven best adapted to irrigation at Garden City may not be so at Weskan. Crop data obtained in Finney county cannot be applied to Wallace county with the same accuracy with which engineering data can. While the irrigation plant at Weskan is located where the depth to water is more than a hundred feet, and the data secured by its operation may show that water cannot profitably be pumped from such depths for the irrigation of farm crops, Wallace county has considerable shallow-water land on which the cost of a pumping plant or the cost of pumping would be but a small fraction of that at the site of the present plant. Data from this deep-well plant on the crop-producing power of water would apply equally well to the shallow-water land in that part of the state, and it would seem to be of sufficient value that it should be obtained before the present plant is abandoned.

The nature of the work undertaken at the Weskan project should be essentially demonstrational rather than experimental. Instead of great numbers of experimental plats, the fields should be fewer in number and much larger. Crops should be limited to those varieties particularly adapted to that locality or commonly grown there. The work should not include a comparatively large number of crop rotations or tillage methods. Alfalfa probably should receive two or more rates of watering, or amounts of water, to determine what is the most economical amount to apply. Other crops should, if practical, be grown both with and without irrigation to determine the value of irrigation water in increasing crop yields above those produced by rainfall alone. This method would be less expensive than experimental work usually is, and the fields, being larger, would produce more revenue than can be expected from smaller plats.

The above has not been said to detract from the work of the Garden City Experiment Station, which involves the use of several hundred experimental plats and a great many varieties of crops, crop rotations, tillage methods and rates of watering. The Experiment Station is doing very valuable work and the data it is securing can be obtained in no other way. Investigations and experiments such as those under way there are of immeasurable value to irrigation agriculture in the state. The irrigation commissioner is pleased to make this comment on the splendid work of that station and the efficient manner in which it is being handled. He further wishes to urge that it be given the unstinted support to which it is entitled.

Work such as that outlined for the Weskan project is distinctly of a character which belongs to the Agricultural Experiment Station. The irrigation commissioner should not engage in the growing of crops or other agricultural experimentation where there is another department in the state which was created for that purpose, and which is already en-

gaged in that work. The Weskan project should, therefore, be turned over to the Agricultural College and its operation made a part of the work of the Agricultural Experiment Station.

Buildings on the Weskan project are in a run-down condition and will need considerable repair. The irrigation plant will require some work to put it in shape for satisfactory operation. Horses and some additional machinery will need to be purchased. In order to meet these needs and provide for salaries, labor and maintenance, the following appropriations will be needed:

	1921.	1922.	1923.
Repairing buildings	$2,000	.....	.....
Horses and machinery	2,000	$1,000	.....
Salaries, labor and maintenance	1,500	4,000	$4,500
Fuel, oil and repairs for plant	500	1,500	1,500
Totals	$6,000	$6,500	$6,000

The irrigation commissioner believes that any salvage value remaining in these plants can be secured only through their operation by the state, and is of the opinion that the information to be obtained through the operation of the Weskan plant will justify the appropriations necessary for its operation. This project should be carried on but a short term of years, possibly six or eight, until the most fundamental information has been obtained, and should then be discontinued. In no way should it supplant the Garden City Station as the irrigation Experiment Station of Kansas, nor should the provision of funds for its operation be allowed to in any way affect or decrease the appropriations necessary for that station.

After having spent large sums of money in the construction of irrigation pumping plants, and having already abandoned most of them without obtaining any information from their operation, it would seem that this plant should be operated for a short term of years to obtain what information it will furnish. However, unless the legislature feels that this information is of sufficient value to warrant the appropriations which its operation will necessitate, it should authorize the sale of it as well as the Modoc and Selkirk plants.

The experience of the past two years is sufficient to show that the present method of handling the plants should not be continued. The machinery will continually depreciate in value, and the results of such operation will not be of sufficient value to warrant their publication.

CHAPTER III.

THE KANSAS-COLORADO WATER CONTROVERSY.

The legislature of Kansas passed a resolution in 1901 directing the attorney-general to institute such legal proceedings as might be necessary to protect the rights and interests of the state of Kansas and its citizens in the use of the waters of the Arkansas river. Events leading up to this action were substantially as follows: Between the years 1879 and 1888 irrigation canals covering over 200,000 acres were constructed in the Arkansas valley in western Kansas. These canals were not used to their full capacities at that time, because not all of the land under them had been settled and brought under cultivation. However, there was an ample supply of water for the irrigation of the lands under these ditches. Following this a great many irrigating canals were constructed in the Arkansas valley in Colorado, until by 1902 the attorney-general of Colorado reported that "713 ditches, with a total appropriation of 5,877 cubic feet of water per second," were taking water from the Arkansas river for the irrigation of 500,000 acres of land in that state. Practically the entire flow of the river was diverted in Colorado, and the water supply became a serious problem for those people in Kansas who had spent large sums of money in the construction of irrigation works. Many people who had settled under these Kansas ditches were compelled to leave. The population of Finney county, which had reached a total of 5,294 in 1888 when irrigation development was at its height, was reduced to 2,951 in 1891.

Pursuant to the above-mentioned resolution, the state of Kansas brought action in the supreme court of the United States against the state of Colorado and the ditch companies in the Arkansas valley. In connection with this suit it is worthy of note that Kansas contended chiefly for the doctrine of riparian rights. Its chief complaint seemed to be the damage to the underflow of the valley by the diversion of the natural flow of the waters in Colorado, rather than its right to the flow of the river for purposes of irrigation, and in its bill prayed that the citizens and corporations of Colorado be permanently enjoined from diverting any of the water from the stream in Colorado. On the other hand, Colorado contended that their state constitution gives them the absolute right to all water which falls on their territory, regardless of prior rights outside of the state.

This case was argued in December, 1906, and was decided in May, 1907. In rendering its decision the court did not sustain Colorado's claim to the ownership of all the waters within its borders, nor did it sustain the Kansas claim, as a riparian owner, to the undiminished flow of the river. It stated, in effect, that an equitable division of the waters must be had, but that Kansas did not prove sufficient inequality to get a verdict in its favor, and said:

"The decree will also dismiss the bill of the state of Kansas as against all the defendants, without prejudice to the right of the plaintiff to institute new proceedings whenever it shall appear that through a ma-

terial increase in the depletion of the waters of the Arkansas by Colorado, its corporations or its citizens, the substantial interests of Kansas are being injured to the extent of destroying the equitable apportionment of benefits between the two states resulting from the flow of the river."

KANSAS-COLORADO WATER COMPROMISE.

Following the dismissal of this suit the larger ditches in Kansas entered into an agreement among themselves, by the terms of which the United States Irrigating Company, a subsidiary corporation of the beet sugar company at Garden City, agreed to bring suit against the ditch companies in Colorado to compel them to release 350 cubic feet of water per second to the Kansas ditches during the irrigating season. The United States Irrigating Company was the owner of a majority of the stock in several of the Kansas ditches.

This suit was brought in the district court of the United States for the district of Colorado, in August, 1910. As originally commenced, the state engineer and other officials in Colorado were made defendants in the suit, but a demurrer was sustained in behalf of the official defendants. Large sums of money were spent by the plaintiffs, the defendants and the state of Colorado in obtaining evidence in this case, but before it was decided an agreement was entered into between the United States Irrigating Company and the defendant ditches, by which the defendant ditches were to pay all costs of the suit and a certain sum of money to the ditches in Kansas. In consideration of this, the Kansas ditches were to yield their priority date for their appropriations as of 1884 and accept a date as of August 27, 1910, and the case was dismissed. Neither the state of Colorado nor any of its officials became parties to this agreement.

PRESENT STATUS OF THE WATER CONTROVERSY.

In view of the fact that the total flow of the Arkansas river was already overappropriated by the Colorado ditches, the dates of whose appropriations were prior to August, 1910, it was readily seen that the above agreement could result in no additional water for Kansas irrigators during the irrigating season, and the Finney County Water Users' Association, owner of the Farmers' ditch, which was interested chiefly in securing an adequate water supply for the farmers under its ditch, refused to enter into this agreement. It subsequently commenced a suit in the United State district court in Colorado against certain ditches in Colorado, in which it seeks to compel them to release water for the irrigation of the 10,000 acres under its ditches. This case is still pending.

There is at this time approximately 60,000 acres under the irrigation canals in Finney, Kearny and Hamilton counties dependent almost entirely upon the Arkansas river for a water supply. Practically all the water received by these ditches is flood water, which comes in such volume that the Colorado ditches are unable to absorb the entire flow. This supply has been such that, with the exception of the Great Eastern canal, which has a storage reservoir holding approximately 30,000 acre feet, and which is filled during the nonirrigating season, the Kansas ditches have not received more than half the water which they need or which they are entitled to; nor can they get it at times when it is most needed,

but are compelled to take it intermittently and irregularly, at such times as floods come, regardless of the particular needs of their crops for water at the time. While the Kansas water users have had their supply reduced to that provided by flood waters, they are even now having that last source of supply gradually taken away from them. Numerous dams and storage works have been built, and others are now in the process of construction, the purpose of which is to store the flood waters of the river and its tributaries and apply such water to the irrigation of additional lands in Colorado. Unless some action is taken to protect the farmers under the Kansas canals they will soon find themselves entirely without water, and irrigation works and water rights, worth millions of dollars, will eventually become worthless.

While the Kansas ditches have had to contend with this shortage of water, the canals across the line in our neighboring states have been operating under quite different conditions. That the irrigation canals in Colorado, most of which were built subsequent to those in Kansas, have appropriations greatly in excess of their needs and are diverting unnecessarily large quantities of water, often to the detriment of their land, is best told in the words of the division engineer of irrigation division No. 2, which comprises the Arkansas valley in Colorado. In the 1917-1918 biennial report of the state engineer to the governor of Colorado, he says:

"The decrees entered in this water division are uniformly and greatly excessive in amounts, and under the ditches given these excessive decrees the acreage irrigated has been continuously increased and the use of water under the direct-flow ditches, where the water is used merely because it is in the river, whether it is needed or not, has led to great waste. This excessive use of water has been indulged in by the users to such an extent that thousands of acres of land have been turned to seepage and become waste. An estimate of the amount of water actually diverted from the river for the use of irrigation of lands under the various ditches shows that there is a variation in the amount diverted in proportion to the lands irrigated, running from practically one acre foot up to as high as ten acre feet to the acre."

The state of Colorado takes the attitude that it is absolute owner of all the water within its borders in interstate streams and that it is entitled to its use regardless of the effect of such use upon interests outside of the state. This attitude is aptly summed up by W. W. Follett, consulting engineer of the International (Water) Boundary Commission, in an address entitled "Irrigation on the Rio Grande," delivered at the annual session of the National Irrigation Congress, held in Albuquerque, N. M., September 29 to October 3, 1908, in which, referring particularly to the use of the waters of the Rio Grande in New Mexico, Texas and the republic of Mexico, he said:

"The Colorado people claim that under their state constitution they are entitled to all of the water which falls on their territory, regardless of prior rights outside of the state on streams which leave it, but their contention does not seem to be sustained by the courts, and it surely is not equitable. There is no logical reason why an imaginary line across a stream should give the landowner above that line a right to take the property of the man below it, whether it be a county, state or international boundary. For in an irrigated country the land has no value with-

out the water, and the value of the property rests in the latter. If a man's water is taken from him he is robbed, whether or not an imaginary line crosses the stream of supply between him and the robber."

The fact that many of the most important rivers flowing through the semiarid states rise in the mountains of Colorado, and that Colorado takes this uncompromising and manifestly unfair attitude toward prior irrigation interests in lower states, has involved her in water controversies with all of the neighboring states and many of the more distant ones. Many expensive suits have been instituted against the state and ditch companies within it, and large sums of money ($50,000 each by several sessions of their legislature) have been appropriated by their legislature to aid in defending these suits. More than $38,000 has been spent by that state on the Kansas suits alone, besides equal amounts in some instances by the defendant ditch companies. Such suits will continue either until Colorado's claim of a constitutional right to the exclusive use of the water in streams crossing her borders has been upheld by the United States supreme court or until she is willing to enter into agreements with other states for an equitable division of the water flowing in interstate streams.

Recently the Colorado authorities have seemed somewhat more disposed to settle these controversies by agreement. In his 1917-1918 biennial report the attorney-general says, with reference to the Rio Grande river:

"New Mexico, recognizing the situation upon the Rio Grande river to be far from satisfactory, desires to treat with Colorado concerning possible settlement of disputes upon the stream with reference to interstate waters, and should be accorded that opportunity.

"If competent commissioners, prudently selected from our ablest and best advised citizens, free from political favoritism, may be chosen, devoted to the future welfare and interest of the state, and who will enter upon their duties with that breadth of view and yet singleness of purpose required upon such momentous undertakings, then the legislature should take some action to meet the situation. If such a method of settlement could be adopted on all our interstate streams, litigation could be avoided, if unaffected by certain bureaus whose ultimate object appears to be the overthrow of all state control of streams and the substitution of complete Federal control.

"The commissioners for Colorado should be selected with utmost care, regardless of politics and with a full realization of the fact that any such interstate agreement afterwards ratified by the legislatures of the two states and by Congress would forever bind Colorado in her use of this valuable river."

As recently as August, 1920, a conference of governors and state engineers was called by the League of the Southwest to adjust the Colorado river problems equitably among Colorado, Idaho, Arizona, Wyoming, Nevada, Utah, New Mexico and California, so that litigation might be avoided. This conference, according to newspaper reports, was held in Denver. The governor and state engineer of Colorado met with them to work out a solution of the water controversy. Whether this attitude on the part of the Colorado officials toward the water problems on the western slope is due to a more neighborly feeling toward the adjoining states, or to the wise expedient of avoiding litigation with the south-

western states, is not known. While the state of Kansas has spent a few thouand dollars, or in some instances has given no aid in defending the water rights of its citizens, it is evident that such states as California and Arizona, with their semitropical fruit and long staple cotton, would not hesitate to put millions into suits involving their water rights. The chief interest lies in the fact that if Colorado consents to an apportioning of the waters on the western slope by agreement or compromise it will have to abandon its claim to the absolute ownership of all the waters falling within its borders. Having abandoned it on the western slope, it will be difficult to maintain it on the eastern slope, and sooner or later it will have to treat with the states on the eastern slope on a compromise basis. It may, therefore, be possible for Kansas, either alone or in conjunction with other states, to work out some satisfactory adjustment of the water controversy with Colorado.

There are now between 460,000 and 500,000 acres irrigated from the Arkansas river in Colorado, and approximately 60,000 from that source in Kansas. Kansas does not ask for water for the development of new projects or the irrigation of additional land, but wants only an equitable share of the water for the land remaining under its ditches, which ditches are prior in time to nearly all of those in Colorado. Upon the statement of their engineers, many of the Colorado ditches are diverting water greatly in excess of their need and often to the injury of their land. Considering these facts, it seems reasonable that some agreement could be worked out by which the Kansas ditches could be allotted a fair share of the water, and further, that the Colorado ditches would suffer little if any permanent injury from such a division of the water.

RECOMMENDATIONS OF THE IRRIGATION COMMISSIONER.

The irrigation commissioner wishes to recommend that the legislature authorize the governor to appoint a committee whose duty it shall be: First, for the purpose of making additional litigation unecessary, to try and make some satisfactory agreement with the Colorado authorities for the equitable apportionment of the waters of the Arkansas river between the water users of the two states, such an agreement to be subject to the approval of the legislatures of the respective states; second, if unable to reach such an agreement, to consult with the proper authorities of other states involved in water controversies with Colorado for the purpose of forming an organization of such states to bring united action against Colorado—a report of their progress and recommendations to be made to the legislature at its next session.

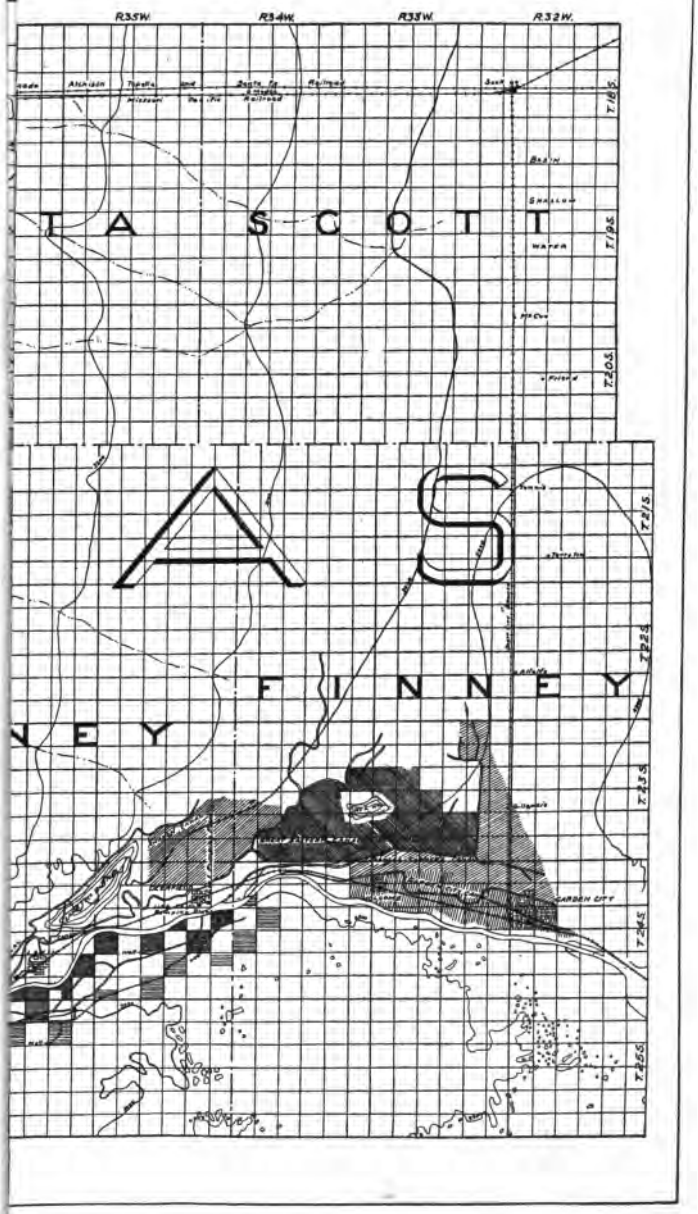
In the meantime the irrigation commissioner should secure stream-flow records of the Arkansas river and the Kansas ditches to determine the amount of water coming into Kansas from Colorado, and the amount diverted by the various Kansas ditches. Such records seem essential if the Kansas water users are to prove to a court that they are not getting the water they are justly entitled to. Colorado has a daily record of the amounts of water diverted by the various ditches in that state, and also a record of the amounts of water flowing in her rivers at various locations. Kansas has no record and does not know how much water is re-

ceived by the various ditches, nor do the ditch companies themselves know how many acre feet of water they get. In addition to that, the only information Kansas has on the amount of water flowing into the state is that obtained from Colorado's records.

Our laws grant the right to corporations and individuals to appropriate water for purposes of irrigation in aid of agriculture. Acting under this authority our citizens have constructed irrigation works costing hundreds of thousands of dollars and have invested millions in property dependent upon the exercise of such right for its value. It is, therefore, an obligation of the state to protect its citizens in the lawful use of such water. The law, in granting this right, also limited the right of appropriation of water to its beneficial use. For that reason no agreements affecting the water rights as between water users in adjoining states should be made, or priorities for the use of water sold by corporations or individuals in one state to those in another, without the consent of the state. Therefore, any action, the purpose of which is to adjudicate the water rights between two states, should be taken only by the states themselves. If an equitable share of water can be obtained only by a process of law, the state of Kansas should bring such action as is necessary in the supreme court of the United States, prosecuting such action vigorously to a definite conclusion.

The irrigation commissioner is of the opinion that whenever litigation between the water users in Kansas and Colorado is necessary, the state should act on behalf of the Kansas water users, even if it would require the water users themselves to provide counsel or part of the necessary funds. Such action would not only be more direct and conclusive, but the added prestige of the state would do much to effect a just decision.

Of the irrigated acreage in Kansas 20,000 is now being irrigated by pumping, and 60,000, or 75 per cent, by the ditches referred to in this report. It would, therefore, seem that since the state is sufficiently interested in irrigation to appropriate money to encourage the expansion of irrigation by pumping, it should also take sufficient action to protect the water users in the Arkansas valley in the rightful use of their water.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CHAPTER IV.

FUTURE WORK OF THE DEPARTMENT.

The service which this department has rendered to the farmers of the state by visiting their farms to aid them in planning irrigation projects and pumping plants has been very valuable and should undoubtedly be continued in its present scope. However, visiting farms for the purpose of advising as to the feasibility of a proposed farm irrigation project or furnishing information and plans for farm irrigation plants is properly college extension work. If that work now being done by the irrigation commissioner duplicated the work of the extension department, or conflicted with it, it should be turned over to the division of college extension of the Agricultural College. In the past there has been no duplication or conflict. While the irrigation commissioner has been at work in one locality the extension department has been at work in another. Both departments have done nearly the same amount of this work, and have had as large a demand for such services as they could supply. Neither department could have done all of this work without nearly doubling its present working force.

COMPILATION AND PUBLICATION OF INFORMATION.

A great deal of information can and should be gathered which will be of great value to the state in working out its irrigation problems along broad lines, and the publication of which will serve to encourage irrigation development in the state. It is in these lines that the irrigation commissioner can render the greatest service to the state.

Of more immediate importance is the necessity of securing additional data on the cost of pumping water and the value of this water in the production of crops. Tests should be made on a great many irrigation plants of different types and in different localities. Data should be gathered on the application of this water to field crops, and the yields obtained as compared to the yields of unirrigated crops grown under similar conditions. The publication of this information would do much to promote the better use of water as an aid to agriculture.

More information should be secured and published concerning the methods of putting in irrigation wells and the tools and machinery used for such work. More irrigation plants fail because of improperly constructed irrigation wells than from any other cause.

Irrigation wells are sunk thirty, forty and fifty feet apart, respectively, by three of the leading irrigation-well contractors in the state, where a battery of wells is used. No information is available showing what the most economical spacing for these wells is, or, when so located, how much one well interferes with the water supply of another. Information of this kind can be secured by experimenting with wells already in operation. Its publication would do much toward securing the greatest amount of water from a given area with the least expenditure of money for wells.

Some information relative to the draw-down of the water table due to pumping and its recovery after pumping ceases is essential to the future of irrigation development. Our supply of ground water has commonly been referred to as inexhaustible. It is only relatively so. No doubt there is a more abundant supply of ground water than will be utilized by the present generation, and therefore for our purposes it is inexhaustible. Nevertheless it is a well-known fact that the continued pumping of large quantities of water does cause a lowering of the ground-water table and at least a temporary depletion of the supply. Data showing the effect on the water supply from pumping for irrigation is essential to the formation of laws to regulate the use of ground water for irrigation and for the protection of early appropriators in their rightful use of water.

CHAPTER V.

IRRIGATION LAWS.

In many respects our irrigation laws have not kept pace with the progress of irrigation. Many of them are obsolete so far as their present use is concerned. Some are so limited in their scope that instead of encouraging the use of water for irrigation they tend to limit it. Water rights are recorded in such a manner that there is no uniform method of filing, and the rights of appropriators are not properly safeguarded.

With a view to suggesting some of the most needed and helpful legislation, the irrigation commissioner has given much time to a study of the operation of our present laws and has conferred with many of the best-informed irrigation men in the state. The discussion which follows was prepared by H. B. Walker, engineer for the Kansas Water Commission, following a conference which the irrigation commissioner had with him. In incorporating this material in his report the irrigation commissioner has made some changes, which for the most part relate to the officials who shall administer the laws suggested.

THE RIGHT TO USE WATER.

The Kansas legislature of 1886 passed a law for the appropriation of water for irrigation purposes. Since that time numerous laws have been enacted relating to irrigation, yet our method of appropriating water has changed but little during the past thirty-four years. Appropriators desiring water need only to post a notice at the point of diversion, stating therein that the person, company or corporation claims the water flowing to the extent of so many cubic feet per second. Such notice shall also describe and define the point of diversion and shall state in general terms the method by which water is to be diverted. A copy of this notice must likewise be posted in the office of the county clerk of the county in which such place of diversion is situated, and finally the record of appropriation is filed in the office of the register of deeds of that county.

THE KANSAS METHOD OBSOLETE.

The Kansas method of appropriating water is obsolete and subject to many inaccuracies of record. Only one other state in the Union has a similar method of appropriation. This is the state of Montana. All other irrigation states require water rights to be granted by some central state authority, which results in more accurate and uniform records and a better-guarded and more valuable water right. Water is a natural resource having a definite value to the state. Kansas surely recognized this when it passed a law outlining a method by which water could be appropriated for use in irrigation. Those who have taken advantage of the opportunity to use this water are developing one of the state's natural resources and in doing this they are surely entitled to the full protection of the law in their development.

DISADVANTAGES OF THE KANSAS METHOD.

Some of the outstanding disadvantages of the Kansas method of securing water rights are: First, the lack of uniformity in methods of filing and in quantities of water appropriated; second, a cumbersome method of recording which makes a review of appropriations on a stream difficult; third a questionable economic value of the water right to the appropriator.

The Kansas method of appropriating water does not permit of uniformity either in method or in quantities of water appropriated. Individuals may use their own personal method of making application so long as they post notices at the proper places and insert some figure therein to indicate the approximate quantity of water desired and the general method and place of diversion. Ten cubic feet per second may be claimed for the irrigation of ten acres, or the appropriator may claim one cubic foot per second for 1,000 acres. No one with proper authority or knowledge checks the application, and since it is the duty of the register of deeds only to keep a record of the appropriation, he is not interested in the quantity of water claimed. Obviously such a plan is not logical, and under the Kansas law, where individual farmers or water users make application probably not oftener than once or twice in a generation, and where the register of deeds is simply a recorder of applications, holding office during a limited period, no great uniformity in method of filing or quantity appropriated can be expected. Kansas is undoubtedly making a mistake by permitting her water resources to be parceled out in such an unsystematic manner.

After an appropriation for water has been made our laws do not provide a definite method of proof as a final claim to the water right. While it is required that work must begin upon the project within a certain time, no provision is made for a proper state official with authority to determine or record this fact. The whole outcome is a set of water records filed in the office of the register of deeds which is in many cases of doubtful value. Furthermore, should any loan association, company or citizen desire to inspect the records of the water filings on any particular stream of the state to determine the amount, priorities or value thereof, it would be necessary for that company or person to make an inspection of the filings in the office of the register of deeds in the various counties through which the stream passes. A review of such records would undoubtedly show a large variation in the method of filing and quantities appropriated, and, moreover, such investigations would be expensive and of doubtful value to the investigator.

A real water right has an economic value. In dry or arid countries the value of a water right is often many times greater than the value of the land. Naturally in such areas purchasers of property carefully investigate the water records before buying the land. It is very doubtful if a large number of the alleged water rights in the state of Kansas have any real definite value. It can hardly be expected that purchasers of property will take the trouble to go over our complicated records of filing to determine the actual value and priority of a water right. The tendency will be to discount the values simply because Kansas has no simple

or easy method of reviewing her records. In other words the laws of Kansas, while permitting citizens to use water for irrigation in aid of agriculture, do not provide adequate legal records to make the appropriation, when secured, of any particular economic value to the appropriator.

UNIFORM FILING SYSTEM NEEDED.

As a remedy for this obsolete method it is suggested that our present laws should be amended to require all applications for water rights to be made at some central state office. Such an office should be directed by some competent engineer, whose duty it would be to carefully examine all such applications for the purpose of determining whether or not the quantity of water requested was actually available and unappropriated from the stream, and further, determine whether or not the amount claimed could be beneficially applied to the area to be irrigated. If after such an investigation the application was granted, a careful record should then be prepared and filed in the central office. A further duty of such an official should be the inspection of projects for which appropriations have been granted, to determine if the water right was actually being developed as required by law.

A KANSAS WATER CODE.

In 1891 important irrigation laws were passed which applied to that part of Kansas situated west of the ninety-ninth meridian. These laws relate to the use of water, whether surface or subterranean, and outline a code for the use of such water, stating that such waters shall be devoted, first, to purposes of irrigation in aid of agriculture, subject to ordinary domestic uses; and second, to other industrial purposes, and may be diverted from natural beds, basins or channels for such purposes and uses; provided, that no such diversion shall interfere with, diminish or divest any prior vested right of appropriation without the due legal condemnation of and compensation for the same. Such a water code is desirable for the entire state of Kansas. This same law of 1891, as amended by the law of 1911, made all waters flowing in subterranean channels and courses, or flowing or standing in subterranean sheets or lakes, appurtenant to the lands through which they flow or stand, with the same general code for the use of such water as outlined in the paragraph above. This law, however, applied only to that part of Kansas situated west of the ninety-ninth meridian and south of township 18. It seemed logical that all subterranean water should be appurtenant to the land under which such waters are situated, and it is believed that the law should apply to all sections of the state. Ground water is perhaps the greatest available supply of water for irrigation. If utilized it must be pumped, and there is little possibility of waste from this method of irrigation.

FURTHER STUDIES DESIRABLE.

While Kansas has many other laws relating to irrigation, the other general laws are not of such fundamental concern to the irrigation interests of the state at this time. Many of these laws are undoubtedly useless and others need revision. Still no definite constructive recommendations can be made until further studies are made.

STREAM GAUGING ESSENTIAL.

Naturally any logical regulation and control of irrigation development must be based upon fundamental hydraulic data. Records of stream flow for all Kansas streams are needed for this purpose. Furthermore, records should be kept of the quantity of water diverted from Kansas streams for purposes of irrigation. These fundamental investigations are of great importance in the logical development of the water resources of Kansas.

IRRIGATION A PART OF A KANSAS WATER PROGRAM.

Kansas must recognize that her waters for irrigation are important as a natural resource. In formulating a state water policy, irrigation, drainage, flood control and water power should be combined in one department, so that a comprehensive and logical irrigation policy can be developed with a state water policy. In this respect the state should recognize the rights of its citizens in the use of water on interstate streams as against the rights of citizens in adjoining states who may claim priority of right over the rights of our own taxpayers.

SUMMARY.

In conclusion, the following recommendations for changes in our irrigation laws are suggested:

First. Change the method of filing and recording water rights from the county plan to a central state office.

Second. Adopt a water code for the entire state as now applying to that section of Kansas west of the ninety-ninth meridian.

Third. Making underground waters appurtenant to all lands of the state, with a definite water code for the use of such waters.

Fourth. Combining the state irrigation, drainage, flood control and water power in one department for the purpose of developing a comprehensive and logical water policy.

CHANGES RECOMMENDED.

It is recommended that sections 5726, 5727 and 5728 of the General Statutes of 1915 be amended to read as follows:

"SECTION 1. *Change of place of diversion, extension of canal, etc.* Any person, company or corporation entitled to the use of water may change the place of diversion if others are not injured by such a change, but no person, company or corporation shall extend the canal, ditch, flume or aqueduct by which the diversion is made, to places beyond that to where first use was made, without first securing permission from the irrigation commissioner.

"SEC. 2. *Appropriation of water; water rights granted by the irrigation commissioner.* Any person, company or corporation desiring hereafter to appropriate water shall make application to the irrigation commissioner for a water right. Such application shall state, in cubic feet per second, the quantity of water desired, and shall be accompanied by a certified plat and statement showing and describing the proposed point of diversion, the area to be irrigated, and giving a description of the proposed irrigation works, ditches and other appliances to be used in diverting and utilizing the water. Whenever application shall be made to the said irrigation commissioner for a water right under this section, it shall be the duty of the irrigation commissioner to examine the application

without delay, and as soon as possible thereafter to issue the water right, if in his judgment the water required for beneficial use is available and remains unappropriated for irrigation purposes. The date of the appropriation, if granted, shall be coincident with that of the time the application was first received in the office of the irrigation commissioner. The water right shall be officially issued in duplicate, one copy of which shall be filed with the irrigation commissioner and the other recorded in the office of the register of deeds in the county where the diversion is made.

"SEC. 3. *Time within which claimant must commence excavation or construction of works for such appropriation; rights of subsequent claimants.* Within six months after a water right has been granted the claimant must commence the excavation or construction of the works in which such claimant intends to divert the water, and must prosecute the work diligently and uninterruptedly to completion unless interrupted by stress of weather or other unavoidable circumstance. By compliance with the above, the claimant's right to the use of water relates back to the time the application was first received in the office of the irrigation commissioner. A failure to comply with the above conditions shall deprive the claimant of the right to use of the water as against a subsequent claimant who complies therewith.

"SEC. 4. That sections 5726, 5727 and 5728 of the General Statutes of 1915 be and the same are hereby repealed.

"SEC. 5. This act shall take effect and be in force on and after its publication in the official state paper."

Recommending an act relating to the recording of appropriation of water and proof of posting of notices thereof, and the repeal of section 5665, article 1, chapter 57, General Statutes of Kansas for 1915:

"SECTION 1. *Record of appropriation of water to be kept by the irrigation commissioner.* That upon the passage and taking effect of this act, the register of deeds of any county wherein has been provided a record of appropriation of water and proof of the posting of notices thereof, as required by section 5665, article 1, chapter 57, General Statutes of 1915, shall within six months thereafter turn over to the irrigation commissioner a certified copy of all such records on file in said counties; and upon the passage of this act the register of deeds of any county in which water for irrigation is appropriated shall thereafter record only such records as have been officially issued by said irrigation commissioner.

"SEC 2. All acts and parts of acts in conflict herewith be and are hereby repealed.

"SEC. 3. This act shall take effect and be in force from and after its passage and publication in the official state paper."

It is recommended that section 5562 of article 1, chapter 57, General Statutes of Kansas for 1915, be amended to read as follows:

"That all natural waters in the state of Kansas, whether standing or running, and whether surface or subterranean, shall be devoted, first, to purposes of irrigation in aid of agriculture, subject to ordinary domestic uses; and secondly, to other industrial purposes; and may be diverted from natural beds, basins or channels for such purposes and uses: *Provided,* That no such diversion shall interfere with, diminish or divert any prior vested right of appropriation without the due legal condemnation of and compensation for the same; and natural lakes and ponds of surface water having no outlet shall be deemed parcel of the lands whereon the same may be situated, and only the proprietors of such lands shall be entitled to draw off or appropriate the same."

It is recommended that section 5566, article 1, chapter 57, General Statutes of 1915, be amended to read as follows:

"All waters flowing in subterranean channels and courses, or flowing or standing in subterranean sheets or lakes, shall belong and be appurtenant to the lands under which they flow or stand, and shall be devoted, first, to the irrigating of such lands in aid of agriculture, subject to ordinary domestic use; second, subject to such use, may be devoted to other industrial purposes: *Provided, however,* That nothing herein contained shall in any way affect appropriations heretofore made."

Reprint from the Twenty-third Biennial Report of the State Board of Agriculture.

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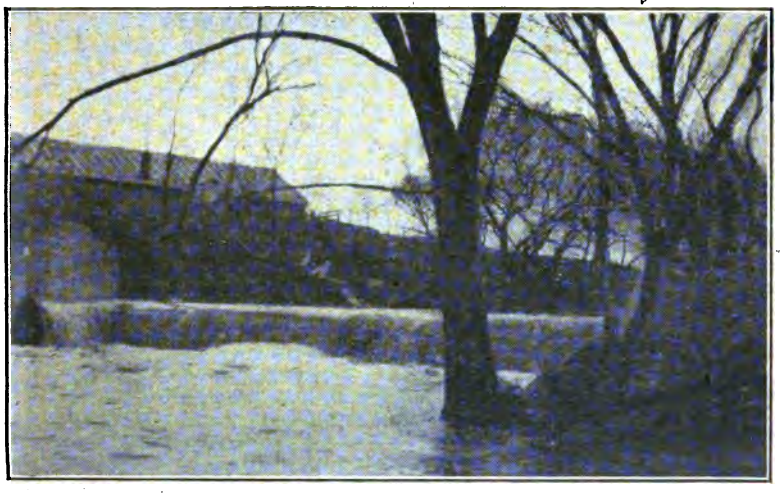
REPORT *of the*

STATE IRRIGATION COMMISSIONER

TO THE

KANSAS STATE BOARD *of* AGRICULTURE

Division of irrigation



For the Biennium
July 1, 1920, to June 30, 1922

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B. P. WALKER, STATE PRINTER
TOPEKA 1922
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REPORT

OF THE

STATE
IRRIGATION COMMISSIONER

TO THE

KANSAS STATE BOARD OF AGRICULTURE.

Division of Irrigation

FOR THE BIENNIUM

JULY 1, 1920, TO JUNE 30, 1922

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LETTER OF TRANSMITTAL.

To the Kansas State Board of Agriculture:

I have the honor to transmit herewith a report of the work and finances of the Division of Irrigation for the biennium, July 1, 1920, to June 30, 1922, together with recommendations relating to certain state irrigation laws.

Very respectfully,

GEO. S. KNAPP,
State Irrigation Commissioner.

REPORT OF THE COMMISSIONER.

CHAPTER I.

GENERAL REVIEW OF THE WORK OF THE DEPARTMENT.

APPROPRIATIONS AND EXPENDITURES.

The legislatures of 1919 and 1921 appropriated the following amounts for the Division of Irrigation for the fiscal years ending June 30, 1921, and June 30, 1922:

For the fiscal year ending June 30, 1921:

Appropriation for the year	$10,500.00
Unexpended balance of previous year	4,039.11
Fees received during year	384.26
Fee fund from previous year	355.20
Total	$15,278.63

For the fiscal year ending June 30, 1922:

Appropriation for the year	$5,000.00
Fees received	8.32
Total	$5,008.32

Expenditures during the same years were:

	1921.	*1922.*
Salary of irrigation commissioner	$3,000.00	$3,000.00
Clerical help	909.00	370.00
Kansas-Colorado water controversy	2,351.61	71.66
Traveling expense, supplies and help	6,232.81	1,559.34
Totals	$12,493.42	$5,001.00

In the midnight hours of the last day of the 1921 legislature, after the regular appropriation for this department had been passed by both the house and the senate, although in different bills, the conference committee arbitrarily reduced the amount to $5,000 per annum—less than fifty per cent of the previous appropriation. This amount has been wholly inadequate to do the work contemplated by the law. In most instances it has been impossible to visit proposed irrigation projects or make surveys and plans as provided for in the law, because the department was unable to supply such help. The gathering of information has also suffered from the decreased appropriation. Such work requires a great deal of time in the field, and the limited funds left very little for traveling expenses.

If the department is to function efficiently and render the service expected of it, more than $5,000 per annum is necessary. It is hardly probable, however, that as much will be required as was available during the fiscal years of 1920 and 1921, since it was during that period that the department was developed and a portion of the expenses in those years was for necessary engineering instruments and field equipment. Most of such equipment is in good

order and will not need to be replaced during the coming biennium. Taking these things into consideration it appears that $8,000 per annum can be made to meet the needs of the department for the next two years, but not less, and it is urged that at least this amount be appropriated.

SALE OF STATE PLANTS.

Bills were passed by the 1921 legislature authorizing this department to sell the personal property at the three state irrigation farms, the improvements and equipment at the Wallace county farm, and sell the Scott county and Wichita county irrigation farms intact with all improvements. In accordance with the provisions of these bills, the personal property was sold at public auction. The other property was advertised in state and county papers and sealed bids opened in the office of the commissioner at Topeka. In this way the buildings, fencing, etc., on the Wallace county farm were sold, but no bids were received for the irrigation pump and engine at that place or for the Wichita county farm. One bid was received for the Scott county farm, but it had to be rejected for the reason that it was below the minimum value fixed according to law by the secretary of state, the attorney-general and the irrigation commissioner.

The following amounts were received for the property sold:

Personal property, Scott county	$300.45
Personal property, Wichita county	194.35
Personal property, Wallace county	378.78
Buildings and fixtures, Wallace county	1,310.00
Well casing	25.00
Personal property, Scott county	5.00
Total	$2,213.58

Expenses incident to advertising the property, conducting the sales, and caring for the unsold property were:

Scott Republican, advertising	$25.00
Leoti Standard, advertising	22.09
Western Times, advertising	32.00
Irrigation commissioner, expense account, arranging for sales and posting sale bills	80.63
George Kelley, gathering property for sale	19.00
Grant Duvall, arranging property for sale	25.00
Irrigation commissioner, conducting sales	99.45
League of Kansas Municipalities, advertising	7.50
Edward Peterson, rent of engine house, Weskan	108.00
Total	$418.67

The net proceeds of these sales, $1,794.91, are being held by the state treasurer until all of the property has been disposed of, after which they will be paid into the general revenue fund of the state.

The fact that the buildings sold at the Wallace county farm included the one used to house the large engine and pump, which were not sold, made it necessary to make some provision to shelter this machinery. This has been done by renting the building of its present owner. In the meantime the department has used every means to dispose of this equipment. Among other things, it sent a mimeographed description of the machinery to every city, mill and elevator in the state in the hope that a purchaser could be found.

since the engine would be suitable for mill or elevator work, or for a small electric-lighting plant, and the pump could be used in either an industrial or a municipal water plant, but not an inquiry was received. It appears from this that there is little probability that the department can sell this equipment in the immediate future, and it seems that in order to eliminate the expense of renting a building, it may be better to turn the equipment over to some state institution, which, while its need for such equipment might not justify the purchase of it, could make some use of it.

The farms which were not sold are being rented as dry-land farms. Real estate has moved very slowly in Scott and Wichita counties during the past two years, and it may be that when conditions there recover buyers can be found. If not, it will be necessary to scale the minimum value down to some lower figure.

INTERSTATE IRRIGATION CONTROVERSY.

A brief summary of the litigation between the states of Kansas and Colorado, and between water users in the two states, over the use of water for irrigation from the Arkansas river was given in chapter III of the 1919-1920 biennial report of this department. At the conclusion of this chapter the irrigation commissioner recommended the appointment of a commission for the purpose of working out a solution of this long-drawn-out conflict.

No action was taken on this resolution by the legislature. At about the same time, however, the Colorado legislature passed a bill providing for a commission to work out an interstate agreement or treaty for the division and control of the waters of the Arkansas river between the two states. This action, which is in striking contrast to Colorado's attitude toward interstate irrigation conflicts in the past, is in accordance with the policy of the present water administration of that state, which is trying to settle present and prospective interstate irrigation litigation through compacts or treaties with each of neighboring states. Following the passage of this act the governor of Colorado appointed a commissioner to negotiate with Kansas; and at his request, Gov. Henry J. Allen appointed a commissioner, Mr. C. A. Schneider, of Garden City, to represent Kansas.

Before the officials of Kansas had been notified of this action on the part of Colorado, the irrigation commissioner was making a careful study of the flow of the Arkansas river and the use of water along that stream, with a view of finding some solution of the controversy which would provide a more dependable supply of water for the Kansas ditches. An examination of the stream-flow data available in Colorado indicated that, on the average, more than 200,000 acre feet of water crossed the state line into Kansas annually. This amount, it would appear, should be more than enough to satisfy the needs of the Kansas ditches, but an examination of the daily flow showed that much of this water, either because it came in floods of uncontrollable volume, or out of the irrigating season, was lost, and the Kansas ditches were periodically short of water during the crop-growing season. From this it seemed reasonable to believe that if some method could be worked out whereby much of this waste water could be stored and conserved for summer use, it might prove the solution of the problem. Storage reservoirs, if built, would have to be in Colorado, for the reason that there is little opportunity for storage after

the water reaches Kansas, and any plan of development would require coöperation between the two states. Such a plan, based on coöperation between the two states for the greater utilization of the water supply, would, it seemed, if carried out, provide sufficient water for both the Colorado and the Kansas ditches, and, unlike litigation which would secure a supply for the victorious litigant at the expense of the defeated one, it would provide enough for all through the elimination of waste.

The irrigation commissioner had already made plans to go to Denver and talk these matters over with the state engineer of Colorado when informed that the Colorado legislature had taken steps toward a friendly settlement. Upon reaching Denver he found the officials there were not only kindly disposed toward working out some adjustment of the interstate water question, but they also had been considering the possibilities of reservoir storage.

Since that time Colorado's state engineer has furnished this department with maps of two undeveloped reservoir sites on the Purgatoire river in Colorado, and Colorado has, at her own expense, sent a party of engineers to survey and map out a possible reservoir site north of Medway, which, if developed, would have to be filled through a canal taking water from the river in Colorado. The two commissioners have held conferences at which the question of storage received special consideration, but no complete agreement has been reached. The principal difficulty at this time seems to be the reluctance of some of the Kansas water users to accept storage in Colorado in lieu of their claims on the river, and the reluctance of some of the Colorado ditches to release sufficient of the summer flow on the Purgatoire to make the construction of storage on that stream possible from the standpoint of the Kansas ditches.

STREAM-FLOW MEASUREMENTS.

The need of some accurate information on the amount of water that the Kansas ditches are able to get from the river under conditions such as exist there now made it seem advisable to undertake some measurements on these ditches. This information is of prime importance in connection with the action now under way looking toward a settlement of the interstate irrigation litigation. To secure this information the irrigation commissioner has installed registering gauges on each of the five principal ditches, and on the Arkansas river a short distance below the Kansas-Colorado state line. The measurements made and the records obtained during the past two years are given in another chapter.

CORN IRRIGATION EXPERIMENTS.

During the season of 1920 the irrigation commissioner coöperated with the Union Stockyards at Wichita and the Sedgwick county agent in a series of experiments in the irrigation of corn. The project was planned by the irrigation commissioner, who also applied the irrigation water. The stockyard company furnished land, water and farm labor for the experiment. The county agent had charge of the field work and the harvesting of the crop.

In this experiment two varieties of corn—Pride of Saline and Common White—were grown on four adjacent plots. The first plot received no irrigation; the second was irrigated once in July; the third received two irrigations,

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CHAPTER II.

STREAM-FLOW MEASUREMENTS.

Six gauges have been installed and are being maintained by this department for the purpose of determining the flow of the Arkansas river and its use for irrigation. These gauges are automatic in their action and make a continuous record of the gauge height, or the depth of the water passing the gauge. One gauge is on the river a short distance below the Kansas-Colorado state line. The other five are on the five principal irrigation canals. The location of these gauges is such that the river gauge makes a record of all water coming into this state from Colorado, while the canal gauges, being just below the headgates of the respective canals, show the amounts of water diverted by such canals.

At first the river gauge was located at Coolidge, on a wagon bridge south of town, but this gauge was lost in the flood of June, 1921, which destroyed the highway bridge to which it was attached. In replacing the river gauge the new one was located at Syracuse, fifteen miles farther downstream, partly because the large steel piers under the bridge at Syracuse offered a more secure place to attach the gauge, and partly because Syracuse can be reached more conveniently either by auto or by rail.

In June, 1922, a river gauge was installed coöperatively by the irrigation commissioner and the United States Geological Survey, the irrigation commissioner furnishing the well and shelter, and the Geological Survey the recording instrument. Discharge measurements at this station will, for the most part, be made by the irrigation commissioner. This installation will not only be valuable as a check on those farther upstream, but it will furnish valuable information on return seepage from the irrigation projects above, and the effect of such irrigation on the water supply in the valley below. No records from this gauge are available for this biennium.

FLOOD OF JUNE, 1921.

In June, 1921, the Arkansas river valley was visited by a flood of such destructive proportions that, because of the damage which it caused to the irrigation canals, it should receive some mention in connection with the stream-flow measurements for that year.

This flood had its origin in rains of unusual intensity over a limited area between Pueblo and Canon City. Rain begain falling on the various tributaries between three and six o'clock on the afternoon of June 3. By nine p. m. the converging streams were pouring the most destructive flood in its history into the city of Pueblo, and within the remarkably short time of three hours the larger part of the business district was flooded to a depth of from ten to fourteen feet.

Proceeding down the valley, the flood increased in volume from an estimated flow of 103,000 second feet at Pueblo to 200,000 second feet at La Junta. Below La Junta the maximum flood flow decreased to approximately 120,000 second feet at Holly, just west of the Kansas line. This decrease was due mostly to the natural storage afforded by the wide, shallow valley as the water flooded over the land.

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FIG. 1. Repairing flood damage on Great Eastern canal. Site of destroyed canal on right, new excavation on left

Discharge measurements. Made from bridge during high water and by wading at low stages.

Channel and control. Shifting.

Extremes of discharges. Maximum, 1.51 feet, March 9 (discharge 244 second feet); minimum, 0.10, May 30 (discharge 1 second foot).

Diversions. There are court decrees for the diversion of approximately 12,825 second feet from the Arkansas and its tributaries above this station in Colorado.

Accuracy. Rating curve fairly well defined between stages of 0.85 feet and 1.50 feet. Daily discharges determined by applying hourly gauge heights to rating curve. Records fair.

DISCHARGE MEASUREMENTS of the Arkansas river at Coolidge during 1920-'21.

Date.	Made by—	Gauge height.	Discharge.
		Feet.	Sec.-ft.
1920.			
July 12	Rodger C. Rice	1.12	64.0
1921.			
Feb. 24	Geo. S. Knapp	1.50	236
Apr. 19	Bruce H. Cummings	1.24	85.3
26	do	1.12	37.1
May 3	do	.85	1.65
10	do	1.06	28.9
17	do	.85	1.77
24	Knapp and Cummings	1.15	51.9

DAILY GAUGE HEIGHT, in feet, of Arkansas river at Coolidge, 1920-'21.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1						1.49		1.10				
2						1.50		1.02				
3						1.51		.87				
4						1.50	1.14	.87				
5						1.50	1.14	.84				
6						1.50	1.15	.85				
7						1.50	1.18	1.09				
8						1.51	1.19	1.08				
9							1.21	1.07				
10							1.18	1.06				
11							1.18	1.07				
12							1.15	1.00				
13							1.18	.87				
14							1.19	.90				
15						1.47	1.29	.98				
16						1.45	1.32	1.03				
17						1.42	1.34	.93				
18						1.37	1.29	.80				
19						1.35	1.24	1.12				
20						1.34	1.21	1.18				
21						1.30	1.19	1.13				
22						1.23	1.17	1.10				
23						1.25	1.14	1.13				
24					1.50	1.24	1.12	1.14				
25						1.23	1.12	1.11				
26						1.22	1.13	1.08				
27						1.21	1.13	.89				
28						1.20	1.13	.78				
29							1.07	.70				
30							1.01	.10				
31												

DAILY DISCHARGE, in second feet, of Arkansas river at Coolidge, 1920–'21.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1						228		35				
2						236		21				
3						244		5				
4						236	47	5				
5						236	47	3				
6						236	50	4				
7						233	59	33				
8						244	62	31				
9							69	30				
10							59	29				
11							59	30				
12							50	17				
13							59	5				
14							62	6				
15						114	104	15				
16						200	119	22				
17						179	131	9				
18						149	104	2				
19						137	82	41				
20						131	69	59				
21						108	62	44				
22						78	56	35				
23						86	47	44				
24					236	82	41	47				
25						78	41	38				
26						74	44	32				
27						69	44	5				
28						65	44	1				
29							30	1				
30							19	1				
31												
Total						3,446	1,660	650				
Mean						157	61	22				
Max						244	131	59				
Min						65	19	1				
Acre ft.						9,650	3,660	1,330				

ARKANSAS RIVER AT SYRACUSE.

Location. At highway bridge half a mile south of Syracuse, in section 18. township 24 south, range 40 west.

Drainage area. Approximately 25,500 square miles.

Records available. June 20, 1921, to December 31, 1921.

Gauge. Gurley automatic graphic water-stage register on downstream side of bridge pier, and staff gauge on outside of gauge well.

Discharge measurements. Made from bridge during high water and by wading at low stages.

Channel. Shifting.

Extremes of discharge. Maximum stage, 5.50 feet, July 20, 1921 (discharge 13,450 second feet); minimum stage, 0.94, September, 1921 (discharge 4 second feet). On June 6, 1921, prior to the installation of the gauge, the river reached a stage of about 9.75 feet, and a discharge of more than 45,000 second feet.

Ice. Stage-discharge relation apparently affected but little by ice in 1921 and 1922.

Diversions. There are court decrees for the diversion of approximately 12,825 second feet from the Arkansas and its tributaries above this station in Colorado, and two small diversions above it in Kansas.

Accuracy. Rating curve fairly well defined between stages of 0.94 and 5.22 ft. Daily discharge ascertained by applying hourly gauge heights to rating curve. Records fair.

DISCHARGE MEASUREMENTS of Arkansas river at Syracuse during 1921-'22.

Date.	Made by—	Gauge height.	Discharge.
1921.		Feet.	Sec. ft.
June 10	Bruce H. Cummings	5.22	12,013
22	Knapp and Cummings	4.13	6,305
28	Bruce H. Cummings	3.53	4,051
July 5	do	2.96	2,021
12	do	2.68	1,244
Aug. 2	do	2.45	1,418
9	do	2.73	1,862
23	do	2.22	774
30	do	1.82	426
Sept. 13	do	1.32	134
20	do	1.20	105
27	do	1.17	72.1
Oct. 4	do	1.17	63.9
Nov. 1	do	1.79	209
8	do	1.59	103
15	H. D. Amsley	1.53	79.1
Dec. 21	Geo. S. Knapp	1.64	128
1922.			
Feb. 7	Geo. S. Knapp	2.04	329
Apr. 12	do	1.77	191
May 14	H. D. Amsley	1.47	88.0
17	Geo. S. Knapp	1.52	93.8
June 16	do	1.07	6.6
20	Williams and Kinnison	1.09	6.1
July 20	H. D. Amsley	1.12	10.2
Aug. 25	do	1.00	9.8
Sept. 13	Geo. S. Knapp	.94	4.3
30	H. D. Amsley	.94	5.3

DAILY GAUGE HEIGHT, in feet, of Arkansas river at Syracuse, 1920-'21.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1										3.14	2.45	1.69
2										3.10	2.43	1.64
3										3.01	3.81	1.58
4										2.96	4.38	1.53
5										2.98	4.29	1.48
6										3.14	3.63	1.45
7										3.15	3.12	1.62
8										3.06	2.87	1.66
9										2.98	2.81	1.49
10									5.22	2.86	2.78	1.44
11										2.73	2.71	1.42
12										2.69	2.64	1.38
13										2.53	2.56	1.34
14										2.46	2.53	1.33
15										2.40	2.52	1.33
16										3.13	3.63	1.32
17										3.74	4.22	1.32
18										3.53	3.54	1.32
19										3.67	3.07	1.32
20									4.29	5.50	2.77	1.24
21									4.31	4.27	2.53	1.22
22									4.23	3.53	2.34	1.20
23									3.92	3.23	2.26	1.20
24									3.70	3.12	2.22	1.19
25									3.54	3.32	2.10	1.18
26									3.42	3.32	2.02	1.17
27									3.42	3.07	1.95	1.18
28									3.57	3.00	1.96	1.17
29									3.30	2.73	1.92	1.16
30									3.10	2.80	1.81	1.16
31										2.65	1.75	

DAILY GAUGE HEIGHT, in feet, of Arkansas river at Syracuse, 1921–'22.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep
1	1.18	1.79	1.61	2.02	.....	.....	1.60	2.27	1.50	1.09	1.36	0
2	1.19	1.77	1.58	2.00	.....	.....	1.55	2.07	1.54	1.11	1.91	
3	1.18	1.73	1.76	2.07	.....	.....	1.50	1.96	1.56	1.07	1.77	
4	1.17	1.70	1.88	2.05	.....	1.96	1.51	1.84	1.45	1.06	2.23	
5	1.16	1.68	1.97	2.04	.....	1.97	1.50	1.78	1.44	1.20	1.84	
6	1.16	1.66	2.07	1.94	2.04	2.04	1.50	1.75	1.41	1.28	2.28	
7	1.16	1.66	2.16	1.79	2.05	2.19	1.36	1.86	1.35	1.22	2.00	
8	1.17	1.61	2.24	1.69	2.16	2.25	1.36	1.86	1.28	1.15	2.15	
9	1.18	1.59	2.27	1.74	2.30	2.06	1.37	1.74	1.23	1.04	2.35	
10	1.19	1.59	2.27	1.82	2.36	1.96	1.48	1.68	1.21	1.14	1.89	
11	1.19	1.57	2.28	1.80	2.31	1.92	1.56	1.67	1.21	1.36	1.69	
12	1.19	1.55	2.31	1.60	.....	1.82	1.77	1.61	1.21	1.70	1.60	
13	1.19	1.55	2.20	1.57	2.30	1.77	1.89	1.55	1.15	1.46	1.52	
14	1.19	1.52	2.12	1.61	.....	1.64	1.93	1.52	1.12	1.37	1.43	
15	1.19	1.53	2.18	1.67	.....	1.56	1.91	1.59	1.11	1.34	1.34	
16	1.19	1.55	2.19	.....	.....	1.59	1.78	1.62	1.09	1.28	1.26	
17	1.19	1.56	1.91	.....	.....	1.51	1.79	1.52	1.08	1.26	1.18	
18	1.19	1.57	1.92	.....	2.07	1.47	1.72	1.46	1.08	1.25	1.12	
19	1.57	1.63	1.90	.....	2.07	1.53	1.72	1.41	1.08	1.22	1.07	
20	1.56	1.69	1.72	.....	2.00	1.79	1.65	1.37	1.10	1.18	1.01	
21	1.55	1.64	1.63	2.18	.....	1.85	1.65	1.37	1.13	1.15	.94	
22	1.54	1.59	1.65	.....	.....	1.78	1.55	1.46	1.07	1.13	.91	
23	1.55	1.56	1.70	.....	.....	1.72	1.59	1.43	1.06	1.12	.88	
24	1.56	1.60	1.75	.....	.....	1.60	1.62	1.40	1.07	1.10	.85	
25	1.64	1.60	1.76	.....	1.68	1.58	1.62	1.37	1.06	1.10	.83	
26	1.63	1.62	1.84	.....	1.97	1.49	1.74	1.35	1.06	1.08	.82	
27	1.68	1.63	1.90	.....	.....	1.49	1.94	1.37	1.05	1.07	.80	
28	1.72	1.62	1.92	.....	.....	1.46	1.98	1.35	1.05	1.06	.81	
29	1.70	1.65	2.04	.....	.....	1.46	2.56	1.33	1.04	1.05	.82	
30	1.72	1.64	2.05	.....	.....	1.53	2.58	1.61	1.03	1.22	.83	
31	1.77	.....	2.06	.....	.....	1.66	.....	1.50	.....	1.11	.84	

DAILY DISCHARGE, in second feet, of Arkansas river at Syracuse, 1920–'21.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.*	July.	Aug.	Sept.
1	.....	.....	.....	.....	.....	.....	.....	.....	22	2,630	1,200	334
2	.....	.....	.....	.....	.....	.....	.....	.....	22	2,490	1,160	304
3	.....	.....	.....	.....	.....	.....	.....	.....	22	2,190	5,640	268
4	.....	.....	.....	.....	.....	.....	.....	.....	22	2,010	8,000	238
5	.....	.....	.....	.....	.....	.....	.....	.....	22	2,080	7,600	210
6	.....	.....	.....	.....	.....	.....	.....	.....	45,000	2,630	4,920	195
7	.....	.....	.....	.....	.....	.....	.....	.....	30,000	2,660	2,980	292
8	.....	.....	.....	.....	.....	.....	.....	.....	25,000	2,350	2,220	316
9	.....	.....	.....	.....	.....	.....	.....	.....	15,000	2,080	2,050	215
10	.....	.....	.....	.....	.....	.....	.....	.....	12,013	1,700	1,970	190
11	.....	.....	.....	.....	.....	.....	.....	.....	11,000	1,350	1,790	180
12	.....	.....	.....	.....	.....	.....	.....	.....	10,000	1,250	1,620	160
13	.....	.....	.....	.....	.....	.....	.....	.....	9,500	890	1,430	140
14	.....	.....	.....	.....	.....	.....	.....	.....	9,000	760	1,370	135
15	.....	.....	.....	.....	.....	.....	.....	.....	8,500	650	1,340	135
16	.....	.....	.....	.....	.....	.....	.....	.....	8,000	2,590	4,920	130
17	.....	.....	.....	.....	.....	.....	.....	.....	7,500	4,780	7,300	130
18	.....	.....	.....	.....	.....	.....	.....	.....	7,300	3,990	4,560	130
19	.....	.....	.....	.....	.....	.....	.....	.....	7,000	4,520	2,820	130
20	.....	.....	.....	.....	.....	.....	.....	.....	6,990	13,450	1,940	98
21	.....	.....	.....	.....	.....	.....	.....	.....	7,070	7,500	1,370	91
22	.....	.....	.....	.....	.....	.....	.....	.....	6,740	4,720	990	84
23	.....	.....	.....	.....	.....	.....	.....	.....	5,480	3,370	856	84
24	.....	.....	.....	.....	.....	.....	.....	.....	4,630	2,980	798	81
25	.....	.....	.....	.....	.....	.....	.....	.....	4,030	3,690	660	78
26	.....	.....	.....	.....	.....	.....	.....	.....	3,590	3,690	586	74
27	.....	.....	.....	.....	.....	.....	.....	.....	3,590	2,820	530	78
28	.....	.....	.....	.....	.....	.....	.....	.....	4,100	2,600	538	74
29	.....	.....	.....	.....	.....	.....	.....	.....	3,170	1,840	506	71
30	.....	.....	.....	.....	.....	.....	.....	.....	2,690	2,020	418	71
31	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,640	370	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	257,003	94,120	74,632	4,716
Mean	.....	.....	.....	.....	.....	.....	.....	.....	8,566	3,040	2,410	157
Max	.....	.....	.....	.....	.....	.....	.....	.....	45,000	13,450	8,000	334
Min	.....	.....	.....	.....	.....	.....	.....	.....	22	650	370	71
Acre ft	.....	.....	.....	.....	.....	.....	.....	.....	510,000	187,000	148,300	9,360

* Flow from June 1 to 19 estimated, except on June 10.

DAILY DISCHARGE, in second feet, of Arkansas river at Syracuse, 1921–'22.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	78	204	110	315	.....	.....	117	453	82	5	41	4
2	81	192	95	305	.....	.....	99	341	96	7	258	4
3	78	170	186	341	.....	.....	82	284	103	6	191	4
4	74	155	261	331	.....	284	85	224	65	6	430	4
5	71	145	324	326	.....	289	82	196	62	13	224	4
6	71	135	394	274	326	326	82	181	53	24	458	4
7	71	135	457	200	331	406	41	234	38	16	305	4
8	74	110	515	154	390	441	41	234	24	10	384	5
9	78	100	537	177	470	336	43	177	17	6	501	5
10	81	100	537	215	507	284	75	150	14	9	248	5
11	81	90	545	205	476	263	103	146	14	41	154	5
12	81	80	568	117	470	215	191	121	14	158	117	5
13	81	80	485	106	.....	191	248	99	10	68	89	5
14	81	68	429	121	.....	133	269	89	8	43	59	5
15	81	72	471	146	.....	103	258	113	7	36	36	5
16	81	80	478	.....	.....	113	196	125	7	24	21	5
17	81	85	282	.....	.....	85	200	89	6	21	12	5
18	81	90	289	.....	341	71	167	68	6	20	8	5
19	90	120	275	.....	341	92	167	53	6	16	6	5
20	85	150	165	.....	305	200	137	43	7	12	5	5
21	80	125	120	401	.....	229	137	43	8	10	4	5
22	76	100	130	.....	.....	196	99	68	6	8	4	5
23	80	85	155	.....	.....	167	113	59	6	8	4	5
24	85	105	180	.....	.....	117	125	50	6	7	4	5
25	125	105	186	.....	150	110	125	43	6	7	3	5
26	120	115	234	.....	289	78	177	38	6	6	3	4
27	145	120	275	.....	.....	78	274	43	6	6	3	4
28	162	115	284	.....	.....	68	295	38	6	6	3	4
29	155	130	373	.....	.....	68	632	34	6	6	3	4
30	162	125	380	.....	.....	92	641	121	5	16	3	4
31	192	.....	387	.....	.....	142	.....	82	.....	7	4	.....
Total	2,962	3,486	10,112	3,734	4,396	5,177	5,301	4,039	700	628	3,585	138
Mean	96	116	326	233	366	185	177	120	23.3	20.3	115	4.6
Max	192	204	568	401	507	441	641	453	103	158	501	5
Min	71	68	95	106	150	68	41	34	5	5	3	4
Acre ft.	5,890	6,920	20,060	14,350	20,340	11,360	10,510	8,010	1,388	1,245	7,139	274

THE GARDEN CITY CANAL.

Location. In section 4, township 24 south, range 34 west, in Finney county, about one-half mile below head gate.

Records available. Irrigation seasons of 1921 and 1922.

Gauge. Gurley automatic graphic water-stage recorder No. 202,304, installed on south bank of canal about 40 feet downstream from wagon bridge.

Discharge measurements. Made from bridge about 40 feet upstream prior to the June, 1921, flood. Bridge was carried away by flood, and measurements made from foot bridge at gauge after flood.

Accuracy. Stage-discharge relation affected by shifting sand in bottom of canal. Banks permanent. Daily discharge ascertained by applying hourly gauge heights to rating curve. Records fair.

FIG. 2. Recording gauge on the Garden City canal.

DISCHARGE MEASUREMENTS of the Garden City canal during 1921–'22.

Date.	Made by—	Gauge height.	Discharge.
1921.		Feet.	Sec. ft.
Apr. 18	Bruce H. Cummings	1.97	14.9
25	do	1.60	10.2
May 2	do	1.62	10.5
9	do	1.57	9.8
16	do	1.60	10.3
23	Knapp and Cummings	1.54	9.0
July 11	Bruce H. Cummings	1.35	5.4
18	do	1.83	16.9
Aug. 1	do	1.84	13.6
15	do	2.29	23.9
23	do	2.34	21.4
Sept. 19	do	1.42	3.2
Oct. 4	do	1.32	2.0
1922.			
May 19	Geo. S. Knapp	1.66	7.4
June 16	do	1.75	7.4
20	Williams and Kinnison	1.72	7.5
24	Geo. S. Knapp	1.50	2.6

DAILY DISCHARGE, in second feet, of Garden City canal, 1920–'21.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1								9			12	20
2								9			13	22
3								9			24	9
4								10			27	
5								10			35	
6								12			25	
7								21			26	
8								11			25	
9								9			25	
10								6			25	
11								6			25	
12								5			25	
13											25	
14							20	6			25	
15							18	8			23	
16							5	8			23	
17								7			28	
18							12	5			24	
19							19	5			24	
20							15				24	
21							14	8			24	
22							14	9			24	
23							12	8			24	
24							10				21	
25							10				14	6
26							11				14	7
27							12				16	7
28							12				19	7
29							12				19	7
30							12				19	6
31										10	17	
Total							208	181		10	694	91
Mean							13	8.6		10	22.3	10.1
Max							20	21		10	35	22
Acre ft							413	359		20	1,375	180

DAILY DISCHARGE, in second feet, of Garden City canal, 1921–'22.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep
1								16	36	5	5	
2								27	35	14		
3								27	35	6		
4									24			
5									16			
6									18	7	13	
7									18	5	11	
8									20		6	
9									16		10	
10									12		13	
11									13	9	6	
12									13	27	4	
13									13	34		
14									11	12		
15									9			
16								4	7			
17								7	7			
18							23	7	8			
19							32	7	7			
20							25	7	6			
21							21	6	6			
22							22	8	6			
23							11	6				
24							11	6	5			
25							27	5	5			
26							45	4				
27							48	4				
28							35					
29							29		21			
30							4	9	10	24		
31								9		12		
Total							333	159	377	155	68	
Mean							25.6	9.3	14.5	14.1	8.5	
Max							48	27	36	34	13	
Acre ft							660	315	748	307	135	

FARMERS' DITCH.

Location. In section 5, township 24 south, range 34 west, in Finney county, about three-fourths of a mile below head gate.

Records available. Irrigation seasons of 1921 and 1922.

Gauge. Gurley automatic graphic water-stage recorder No. 202,298, installed on north bank of canal at downstream end of wagon bridge.

Discharge measurements. Made from wagon bridge.

Accuracy. Stage-discharge relation practically permanent. Rating curve well defined. Daily discharge ascertained by applying hourly gauge heights to rating curve. Records good.

DISCHARGE MEASUREMENTS of the Farmers' ditch during 1921–'22.

Date.	Made by—	Gauge height.	Discharge.
1921.		Feet.	Sec. ft.
June 15	Knapp and Cummings	1.61	53.3
20	do	1.90	65.9
27	Bruce H. Cummings	1.45	38.9
July 4	do	1.07	19.2
Aug. 1	do	2.08	84.8
16	do	2.92	150
30	do	2.32	9309
Sept. 20	do	1.65	53.5
27	do	1.30	34.1
Oct. 4	do	1.16	24.6
11	do	1.28	30.7
Nov. 15	Amsley and Cummings	.97	14.8
1922.			
Apr. 14	Geo. S. Knapp	3.12	172
May 18	do	2.32	113

DAILY DISCHARGE, in second feet, of Farmers' ditch, 1920–'21.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	.....	.....	.....	.....	.....	11	.....	.....	22	65	131
2	.....	.....	.....	.....	.....	.....	20	.....	.....	13	44	141
3	.....	.....	.....	.....	.....	.....	18	.....	.....	15	30	83
4	.....	.....	.....	.....	.....	.....	30	.....	.....	19	26	67
5	.....	.....	.....	.....	.....	.....	43	.....	.....	21	49	61
6	.....	.....	.....	.....	.....	.....	24	.....	.....	29	74	57
7	.....	.....	.....	.....	.....	.....	24	.....	.....	28	73	111
8	.....	.....	.....	.....	.....	.....	25	.....	.....	.....	95	152
9	.....	.....	.....	.....	.....	.....	26	.....	.....	.....	99	133
10	.....	.....	.....	.....	.....	.....	23	.....	.....	.....	110	54
11	.....	.....	.....	.....	.....	110	17	.....	.....	.....	118	48
12	.....	.....	.....	.....	.....	136	17	.....	.....	.....	120	57
13	.....	.....	.....	.....	.....	159	42	.....	36	.....	119	67
14	.....	.....	.....	.....	.....	158	.....	.....	42	.....	108	60
15	.....	.....	.....	.....	.....	179	.....	.....	47	.....	112	51
16	.....	.....	.....	.....	.....	179	.....	.....	44	.....	128	47
17	.....	.....	.....	.....	.....	115	.....	.....	48	.....	60	77
18	.....	.....	.....	.....	.....	112	.....	.....	66	.....	88	79
19	.....	.....	.....	.....	.....	100	.....	.....	68	.....	108	107
20	.....	.....	.....	.....	.....	60	.....	.....	67	16	124	65
21	.....	.....	.....	.....	.....	61	.....	.....	65	33	129	44
22	.....	.....	.....	.....	.....	67	.....	.....	47	40	109	43
23	.....	.....	.....	.....	.....	52	.....	.....	38	47	112	42
24	.....	.....	.....	.....	.....	28	.....	.....	36	52	99	42
25	.....	.....	.....	.....	.....	22	.....	.....	35	.....	98	35
26	.....	.....	.....	.....	.....	21	.....	.....	34	.....	90	32
27	.....	.....	.....	.....	.....	19	.....	.....	38	29	107	28
28	.....	.....	.....	.....	.....	22	.....	.....	52	39	114	23
29	.....	.....	.....	.....	.....	21	.....	.....	56	42	114	19
30	.....	.....	.....	.....	.....	.....	.....	.....	41	45	72	22
31	.....	.....	.....	.....	.....	.....	.....	.....	.....	56	43	.....
Total	.....	.....	.....	.....	.....	1,621	320	.....	860	546	2,837	1,978
Mean	.....	.....	.....	.....	.....	85.3	24.6	.....	47.7	33.8	91.5	63.8
Max	.....	.....	.....	.....	.....	179	43	.....	68	56	129	152
Acre ft	.....	.....	.....	.....	.....	3,210	635	.....	1,710	1,082	5,625	3,922

DAILY DISCHARGE, in second feet, of Farmers' ditch, 1921–'22.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	25	18	.....	.....	.....	.....	110	36	83	.....	.....	.....
2	25	17	.....	.....	.....	.....	129	72	34	.....	.....	.....
3	25	19	.....	.....	.....	.....	126	68	12	.....	.....	.....
4	26	18	.....	.....	.....	.....	119	88	.....	.....	.....	.....
5	25	17	.....	.....	.....	.....	110	117	.....	.....	.....	.....
6	23	16	.....	.....	.....	.....	103	58	.....	.....	.....	.....
7	21	16	.....	.....	.....	.....	94	38	.....	.....	31	.....
8	25	15	.....	.....	.....	.....	89	34	.....	.....	30	.....
9	31	16	.....	.....	.....	.....	72	47	.....	.....	51	.....
10	31	16	.....	.....	.....	.....	67	29	.....	.....	145	.....
11	30	16	.....	.....	.....	.....	61	24	.....	.....	45	.....
12	33	15	.....	.....	.....	.....	96	23	.....	.....	12	.....
13	25	15	.....	.....	.....	.....	124	26	.....	.....	.....	.....
14	22	14	.....	.....	.....	.....	170	24	.....	.....	.....	.....
15	24	14	.....	.....	.....	.....	121	29	.....	.....	.....	.....
16	22	14	.....	.....	.....	.....	49	77	.....	.....	.....	.....
17	21	13	.....	.....	.....	.....	42	121	.....	.....	.....	.....
18	19	13	.....	.....	.....	19	39	102	.....	.....	.....	.....
19	19	13	.....	.....	.....	10	.....	94	.....	.....	.....	.....
20	19	14	.....	.....	.....	37	.....	91	.....	.....	.....	.....
21	19	15	.....	.....	.....	29	.....	83	.....	.....	.....	.....
22	19	20	.....	.....	.....	26	.....	110	.....	.....	.....	.....
23	18	.....	.....	.....	.....	26	13	88	.....	.....	.....	.....
24	18	.....	.....	.....	.....	25	16	84	.....	.....	.....	.....
25	18	12	.....	.....	.....	23	29	70	.....	.....	.....	.....
26	16	17	.....	.....	.....	23	34	57	.....	.....	.....	.....
27	16	16	.....	.....	.....	18	39	44	.....	.....	.....	.....
28	12	15	.....	.....	.....	38	42	.....	.....	.....	.....	.....
29	23	.....	.....	.....	.....	.....	31	43	.....	.....	.....	.....
30	35	.....	.....	.....	.....	.....	19	63	.....	.....	.....	.....
31	24	.....	.....	.....	.....	82	.....	72	.....	.....	.....	.....
Total	709	404	.....	.....	.....	318	1,940	1,954	129	.....	314	.....
Mean	22.8	15.8	.....	.....	.....	28.9	74.6	63.0	43.0	.....	52.3	.....
Max	35	19	.....	.....	.....	37	170	121	83	.....	145	.....
Acre ft	1,405	801	.....	.....	.....	631	3,848	3,875	256	.....	623	.....

GREAT EASTERN CANAL.

Location. In section 15, township 25 south, range 37 west, south of Hartland, in Kearny county, and about one-half mile downstream from head gate.

Records available. Irrigation seasons of 1921 and 1922.

Gauge. Gurley automatic water-stage recorder No. 202,309, installed on south bank of canal about 150 feet upstream from highway bridge across canal.

Discharge measurements. Made from highway bridge.

Accuracy. Stage-discharge relation affected somewhat by sand deposits in bed of canal. Daily discharge ascertained by applying hourly gauge heights to rating curve. Records fair.

Reservoir storage. In addition to the water diverted during the irrigation season, March to November, inclusive, about 20,000 acre feet are diverted through this canal each winter for storage in Lake McKinney.

DISCHARGE MEASUREMENTS of the Great Eastern canal during 1921–'22.

Date.	Made by—	Gauge height.	Discharge.
1921.		Feet.	Sec. ft.
Apr. 18	Bruce H. Cummings	1.81	87.1
25	do	1.13	28.5
May 9	do	.59	1.44
16	do	.58	1.34
Nov. 22	do		110

DAILY DISCHARGE, in second feet, of Great Eastern canal, 1920–'21.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1							53	20				
2							48	14				
3						25	22	10				
4						20	21					
5							20	11				
6							18	14				
7							18	28				
8								14				
9								10				
10												
11												
12												
13												
14												
15							92					
16						34	66					
17						58	74					
18						56	82					
19						67	92					
20						56	79					
21						50	67					
22						66	57					
23						101	49					
24						97	37					
25						90	31					
26						93	28					
27						72	22					
28						74	21					
29						68	23					
30						62	25					
31						60						
Total						1,149	1,045	121				
Mean						64	45	15				
Max						101	92	28				
Acre ft						2,280	2,070	240				

DAILY DISCHARGE, in second feet, of Great Eastern canal, 1921-'22.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1								189				
2								183				
3								189				
4								156				
5								70				
6								98				
7						120		157			241	
8						98		187			159	
9						70		183			265	
10						36		158			174	
11						57		132				
12						180		115				
13						180		129				
14						113		111				
15						44		105				
16						33						
17						106						
18						132						
19		17				89						
20		95				95						
21		84				144						
22		80				151						
23		105				128						
24		118				91						
25		55				63	17					
26		22				43	24					
27		17				22	67					
28							128					
29							158					
30							187					
31												
Total		593				1,995	581	2,162			839	
Mean		66				95.0	96.8	144			210	
Max		118				180	187	189			265	
Acre ft.		1,180				3,956	1,152	4,287			1,664	

SOUTH SIDE DITCH.

Location. In section 15, township 25 south, range 37 west, about half mile south of Hartland, in Kearny county, and approximately one-half mile downstream from head gate.

Records available. Irrigation seasons of 1921 and 1922.

Gauge. Gurley automatic water-stage recorder on south bank 100 feet upstream from highway bridge across canal.

Discharge measurements. Made from highway bridge.

Accuracy. Stage-discharge relation affected slightly by shifting sand. Banks fairly permanent. Rating curve fairly well defined. Daily discharge ascertained by applying hourly gauge heights to rating curve. Records good.

DISCHARGE MEASUREMENTS of the South Side canal during 1921-'22.

Date.	Made by—	Gauge height.	Discharge.
1921.		Feet.	Sec. ft.
Sept. 5	Bruce H. Cummings	2.25	120
12	do	1.94	67.4
Nov. 15	Amsley and Cummings	1.98	88.5
22	Bruce H. Cummings	1.13	8.8
29	Knapp and Cummings	2.22	105

DAILY DISCHARGE, in second feet, of South Side canal, 1920–'21.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1												
2						17						30
3						111						117
4						208						120
5						247						112
6						247						120
7						248						170
8						167						198
9						65						173
10						135						140
11												117
12												75
13												72
14												72
15												70
16												71
17												50
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												
To al.						1,445						1,707
Mean.						161						106
Max.						248						198
Acre ft.						2,870						3,390

DAILY DISCHARGE, in second feet, of South Side canal, 1921–'22.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1								132				
2								123				
3								40				
4								36				
5								31			88	
6								28			116	
7								24			196	
8											111	
9											132	
10		28									107	
11		73									112	
12		75									152	
13		85									100	
14		83									50	
15		80									34	
16		80									27	
17		81									23	
18		81									18	
19		39									14	
20											11	
21		32									9	
22		20					11				6	
23		21					57					
24							146					
25		56					146					
26		118					146					
27		122					146					
28		118					150					
29		116					147					
30		120					73					
31												
Total.		1,428					1,022	414			1,306	
Mean.		75					114	59.1			72.5	
Max.		120					150	132			196	
Acre ft.		2,830					2,027	821			2,590	

AMAZON CANAL.

Location. In section 8, township 25 south, range 37 west, in Kearny county, about one mile downstream from head gate.

Records available. Irrigation seasons of 1921 and 1922.

Gauge. Gurley automatic water-stage recorded on north bank 50 feet downstream from wagon bridge across canal.

Discharge measurements. Made from bridge.

Accuracy. Stage-discharge relation practically permanent. Rating curve well defined. Daily discharge ascertained by applying hourly gauge heights to rating curves. Records good.

DISCHARGE MEASUREMENTS of the Amazon canal during 1921–'22.

Date.	Made by—	Gauge height.	Discharge.
1921.		Feet.	Sec. ft.
Mar. 2	Knapp and Cummings	3.88	162
Aug. 2	Bruce H. Cummings	4.05	245
9	do	4.60	227
22	do	4.40	223
29	do	2.60	61.1
Sept. 20	do	2.72	69.6
27	do	2.27	37.4
Oct. 4	do	2.30	38.6
11	do	1.88	18.8
31	do	3.51	141
Nov. 7	do	3.10	95.9

DAILY DISCHARGE, in second feet, of Amazon canal, 1920–'21.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1											221	
2						167					222	
3						30					248	
4											256	
5											241	
6											240	
7											245	
8											242	
9											238	
10											244	
11											225	
12											158	
13											123	
14											123	
15											158	
16											192	
17											262	16
18											251	27
19											218	58
20											211	67
21											210	54
22											207	39
23										8	196	34
24										164	162	34
25										177	134	27
26										143	112	32
27										154	91	36
28										182	75	35
29										204	60	31
30										227	48	32
31										240		
Total						197				1,499	5,626	522
Mean						48				166	187	37
Max						167				240	262	67
Acre ft						391				2 970	11,150	1,030

Fig. 3. Recording gauge on Anuzon canal.

DAILY DISCHARGE, in second feet, of Amazon canal, 1921–'22.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	33	172	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	36	160	.....	.....	.....	.....	.....	.....	.....	.....	76	.....
3	36	146	.....	.....	.....	.....	.....	.....	95	.....	163	.....
4	36	127	.....	.....	.....	.....	.....	.....	75	.....	193	.....
5	37	116	.....	.....	.....	.....	.....	.....	59	.....	240	.....
6	38	102	.....	.....	.....	.....	.....	.....	50	.....	59	.....
7	20	99	.....	.....	.....	.....	.....	.....	38	.....	.....	.....
8	15	98	.....	.....	.....	.....	.....	.....	21	.....	.....	.....
9	20	94	.....	.....	.....	.....	.....	.....	.....	.....	82	.....
10	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	36	.....
11	19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	30	.....	.....	.....	.....	.....	.....	.....	.....	92	.....	.....
13	28	.....	.....	.....	.....	.....	.....	.....	.....	153	.....	.....
14	34	.....	.....	.....	.....	.....	.....	.....	.....	54	.....	.....
15	29	.....	.....	.....	.....	.....	225	.....	.....	28	.....	.....
16	44	.....	.....	.....	.....	.....	231	.....	.....	15	.....	.....
17	44	.....	.....	.....	.....	.....	225	.....	.....	.....	.....	.....
18	44	.....	.....	.....	.....	.....	216	.....	.....	.....	.....	.....
19	47	.....	.....	.....	.....	81	210	.....	.....	.....	.....	.....
20	48	.....	.....	.....	.....	90	211	.....	.....	.....	.....	.....
21	50	.....	.....	.....	.....	103	169	.....	.....	.....	.....	.....
22	43	.....	.....	.....	.....	103	157	.....	.....	.....	.....	.....
23	48	.....	.....	.....	.....	116	65	.....	.....	.....	.....	.....
24	50	.....	.....	.....	.....	115	.....	.....	.....	.....	.....	.....
25	62	.....	.....	.....	.....	100	.....	.....	.....	.....	.....	.....
26	62	.....	.....	.....	.....	110	.....	.....	.....	.....	.....	.....
27	42	.....	.....	.....	.....	121	.....	.....	.....	.....	.....	.....
28	54	.....	.....	.....	.....	111	.....	.....	.....	.....	.....	.....
29	72	.....	.....	.....	.....	105	.....	.....	.....	.....	.....	.....
30	104	.....	.....	.....	.....	29	.....	.....	.....	.....	.....	.....
31	128	.....	.....	.....	.....	12	.....	.....	.....	.....	.....	.....
Total	1,373	1,114	.....	.....	.....	1,196	1,709	.....	338	342	849	.....
Mean	44	124	.....	.....	.....	92.1	190	.....	56.3	68.4	121	.....
Max	128	172	.....	.....	.....	121	213	.....	95	153	240	.....
Acre ft	2,720	2,210	.....	.....	.....	2,372	3.389	.....	670	678	1,684	.....

CHAPTER III.

A REVIEW OF IRRIGATION IN KANSAS.

In view of the fact that the general public has but little information regarding either the irrigated acreage in the state, the value of irrigation as an adjunct to the state's agriculture, or the possibility of future development, this department has endeavored to collect information showing the extent of irrigation, and has made a somewhat general study of the present status of irrigation development as regards water supply, nature of works or type of equipment used in developing such supply, and the kinds of crops grown under irrigation in the various localities. It has not been possible to make a complete survey of the extent of irrigation in the state. Information on the irrigated acreage has been obtained partly by assessors' reports and partly by the questionnaire method. The latter served to check the assessors' reports, which in many cases were incomplete. Assistance has also been given by the officers of the various ditch associations. Information on the general nature of development in the various localities has been secured almost wholly by the irrigation commissioner while on trips to the various parts of the state.

There are at this time approximately 95,000 acres of irrigated land. Some irrigation is practiced in all but thirty counties of the state; however, it assumes the proportions of general farm irrigation in only about seven counties. The principal irrigation counties and acreage of land irrigated in each in 1920 are as follows:

County.	Acreage irrigated in 1920.
Finney	52,041
Kearny	23,079
Scott	4,921
Hamilton	3,666
Pawnee	2,244
Meade	2,169
Gray	1,936
Sedgwick	685
Other counties	4,397
Total	95,138

The present extent of irrigation in Kansas gives little indication of the irrigation possibilities of the state. The existence of abundant supplies of ground water in many parts of the state, together with the uniformly beneficial results obtained where irrigation is now practiced, indicates that as the population increases, as land values become higher and as the value of irrigation becomes more generally appreciated, the acreage will be greatly increased. Already around several of the cities and towns where land is high, and where there is a ready market for farm produce, or where truck growers' associations have been organized to provide a means of marketing the crops, irrigation is regarded as an essential part of the farm operations and the irrigation pumping plant is as much a part of the necessary farm equipment as is the silo.

The character of irrigation development varies greatly in different parts of the state. Types of irrigation structures prevailing in one locality are wholly absent in another. In one locality irrigation may be practiced extensively for general farm crops, while in another it is restricted almost entirely to garden-

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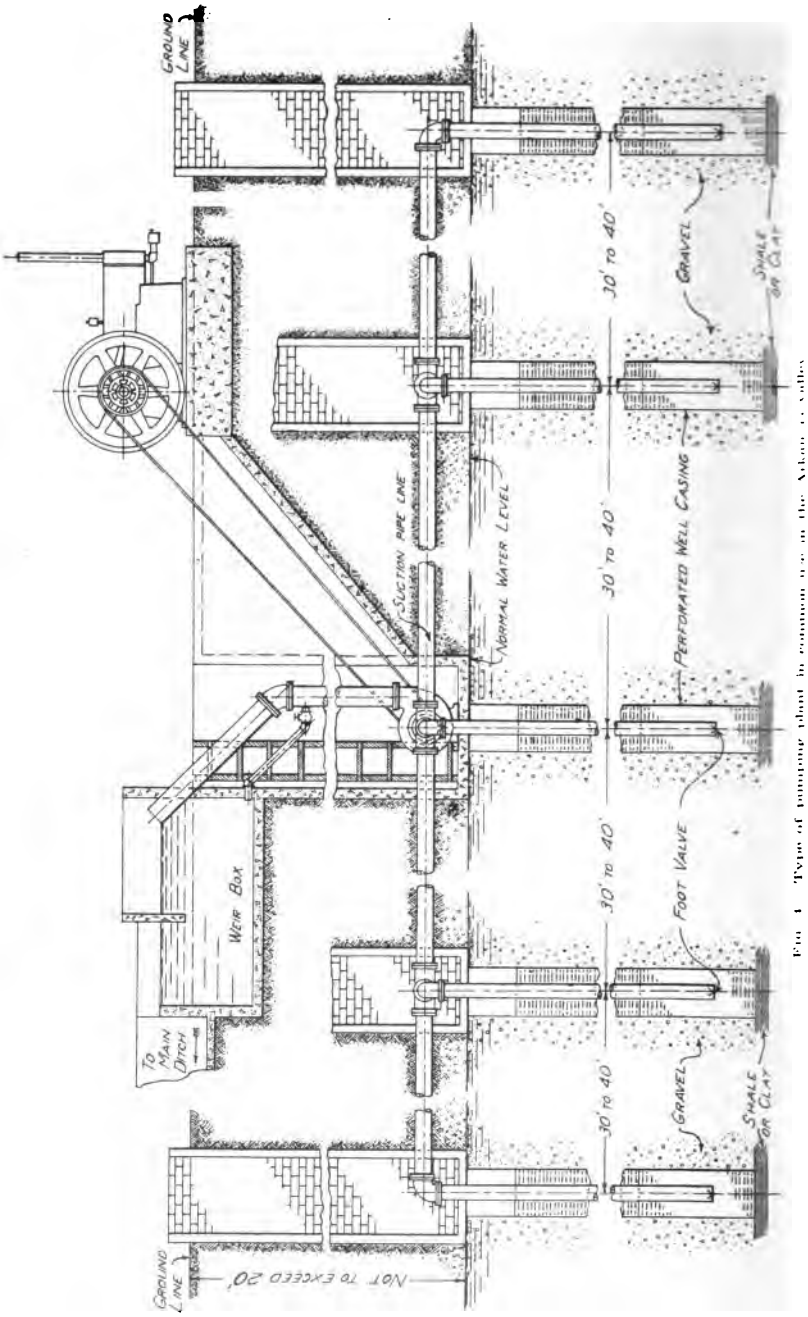

Fig. 4. Types of pumping plant in common use in the Arkansas valley.

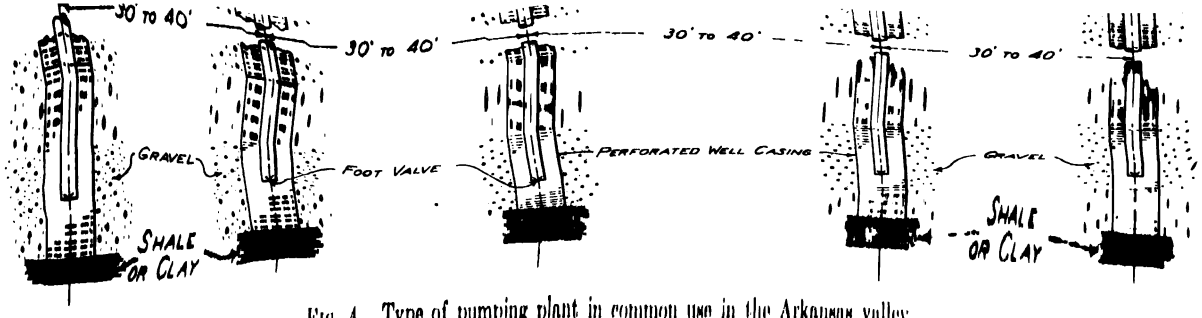

FIG. 4. Type of pumping plant in common use in the Arkansas valley.

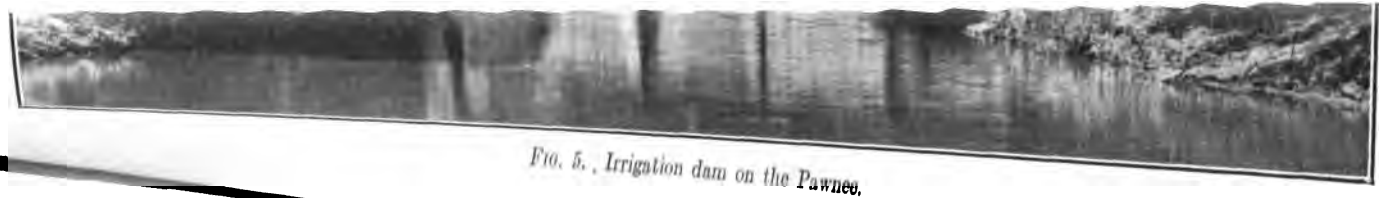

FIG. 5. Irrigation dam on the Pawnee.

continued period of pumping has but little effect in further lowering the water in the channel.

The increasing of the amount of water available for pumping from reservoirs has not been the only beneficial result of the raising of the ground-water elevation. In many places the water table has been raised close enough to the surface to subirrigate growing crops. Several striking examples of this are afforded by alfalfa fields, which in former years often suffered from drought, but which since the raising of the water table are productive throughout the summer, and regularly yield almost as much as surface irrigated fields.

Some of the dams on the Pawnee have been in use for more than ten years. Their value as a means of storing and conserving the surface run-off of these drainages has been so well demonstrated that it is evident, if dams were built at distances of four or five miles apart throughout the courses of these streams, enough water could be stored to irrigate all of the adjacent bottom land.

The typical irrigation plant in the Pawnee valley consists of a dam in the river channel and a pumping plant on the adjacent bank to pump water from the reservoir thus formed. There are a few irrigation plants throughout the valley pumping from wells, but the underground strata are not favorable for extensive irrigation from that source.

Crops grown here are for the most part general farm crops, such as alfalfa, corn, kafir, etc. There is a small acreage of sugar beets raised each year and shipped to the beet sugar factory at Garden City.

SCOTT COUNTY.

Irrigation in Scott county is noteworthy in that there is a well-developed irrigation agriculture remote from any river valley. About 5,000 acres are irrigated with a water supply obtained wholly from wells.

An abundance of water can generally be found almost anywhere in the central or southwestern part of the county at depths ranging from twenty to sixty feet below the surface. In some places this water-bearing formation is of such a nature that single wells have produced a yield as great as 2,000 gallons per minute. Most wells will yield at least enough to supply a quarter section of land.

Pumping plants, for the most part, consist of a single well (usually about twenty-four inches in diameter), a type of centrifugal pump commonly known as a deep-well turbine pump, and either an internal-combustion engine or an electric motor for power. Many of the pumping plants are using an engine for power, but a transmission line extends from Garden City to this district and electric energy is available for all who wish to use it. A notable project here is on the Lough ranch, where Mr. Lough has built a central power station and is operating a number of pumping plants on various parts of his ranch with the electricity generated at this central station. A large oil engine, burning low-grade fuel oil, is used for power.

The principal crop in this district is alfalfa. Both the soil and the climate are well adapted to this crop. Some of the finest alfalfa fields in the state are here, and remarkable yields have been obtained from them. Yields of from five to seven tons per acre are common, and some as high as nine tons per

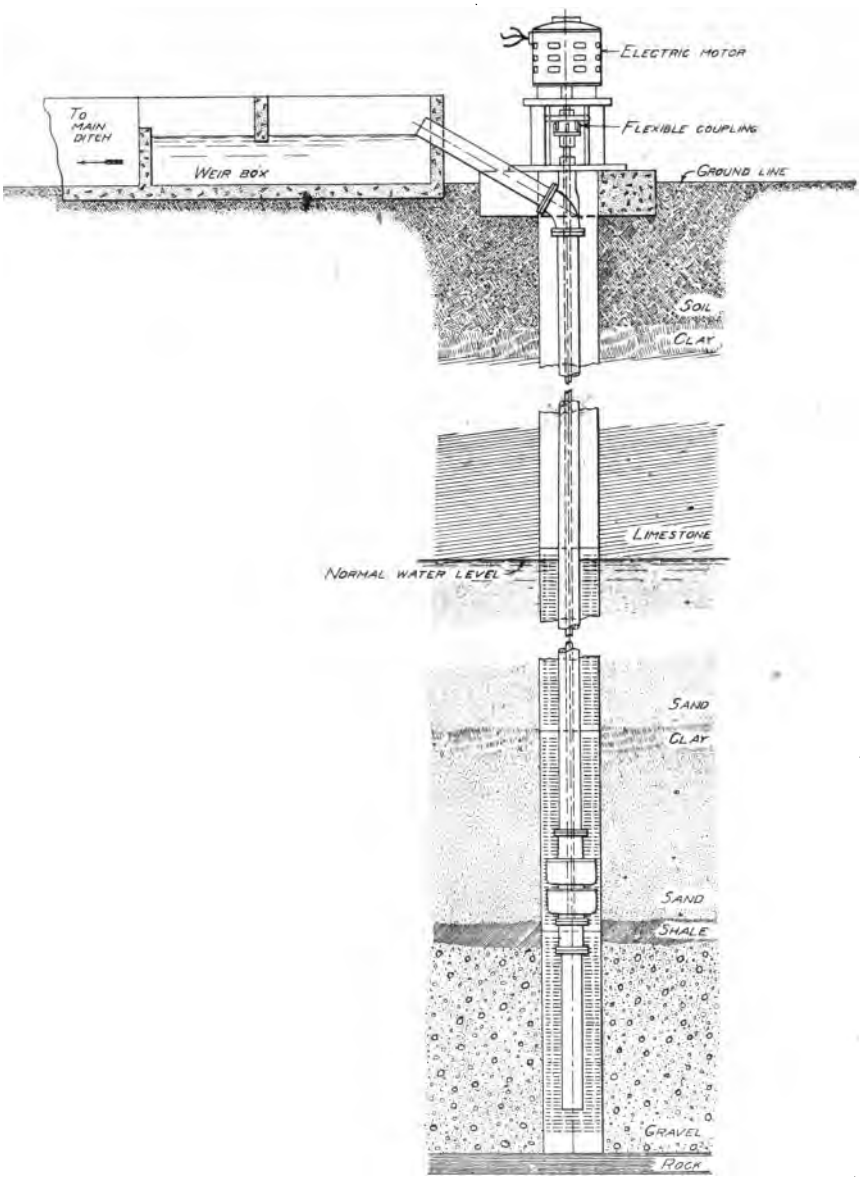

FIG. 6. Type of pumping plant prevailing in Scott county.

FIG. 7. Diversion dam on the Clearfork in Menifee county.

acre have been reported. For the most part the hay is baled and shipped to distant markets.

During the past biennium high freight rates and the high cost of fuel or power have had an unfavorable effect on development in this district, and in some instances have been the cause of pumping plants standing idle. Unless such charges are adjusted more favorably to the farmer, diversified farming, dairying and truck gardening will have to be practiced to enable the district to develop its latent possibilities.

So far pumping has had no noticeable effect on the supply of ground water, and it is unquestionably sufficient to irrigate a much greater area.

SOUTHWESTERN KANSAS.

About 2,400 acres of land are irrigated in that portion of southwestern Kansas south of the Arkansas valley and west of the eastern boundary of Barber county. There are a number of pumping plants scattered throughout this district, but the greater part of the irrigated acreage is in two or three larger projects obtaining their water supply by gravity from the Cimarron and similar streams.

Opportunities for future development are found principally along Crooked creek, Bluff creek and the Medicine Lodge river. On the upland the ground water is generally deep and the supply limited, and as a rule little or no ground water can be developed in the valleys. On the other hand, many of the streams fed by springs near their sources have a fairly dependable supply of water.

The Arkansas river to the north is much higher than these streams. It is only necessary to point out the fact that Dodge City, on the Arkansas river, is 520 feet higher than Ashland, forty miles south, and is 220 feet higher than Jetmore, twenty miles north, to show that this river runs through that part of the state which is on a "hogback," so to speak. The effect of this is that most of the drainage is away from the Arkansas. Most of the ground water in that part of the state, and undoubtedly some of the "underflow" of the Arkansas, moves south and feeds the numerous springs which are found in the hills in Meade, Clark and Kiowa counties, in which these streams have their sources. Some of these springs are large enough to supply an entire irrigation project. The writer measured one such in 1915, which had a flow of more than ten cubic feet per second.

Besides the water to be obtained from springs, there are many places where dams could be put in the channels of these streams and a very good supply of water developed in the same manner as it is done along the Pawnee.

NORTHWESTERN KANSAS.

In comparison with the area, the irrigated acreage of northwestern Kansas is insignificant. Not more than 1,000 acres is irrigated in the entire district.

Most of the upland is too deep to water for extensive or profitable irrigation. Where it is practiced it is for the irrigation of truck gardens. Here the successful plant is the windmill plant. One project in particular which has come to the attention of this department consists of two windmills and a small earthen reservoir to store the water. The owner uses this water for the irrigation of two acres of land planted to a variety of small fruit and truck crops.

He has been very successful with this project and obtains most of the family income from it.

The valleys of the Republican, Solomon, Saline and Smoky Hill rivers offer the greatest opportunities for irrigation. There are a few pumping plants pumping water from these streams, but for the most part the irrigation potentialities of these streams remain untouched. Some of the streams are cut down deep enough into the tertiary deposits to the west to be fed by their ground waters, and they have a fairly constant flow. The type of structure best suited to these valleys is the channel reservoir for the storage of surface flow and a pump to pump the stored water on to the adjacent valley land.

BLUE RIVER VALLEY.

With only about 200 acres included in irrigation projects, the Blue valley would not merit special consideration were it not for the fact that here in the eastern part of the state, where the average rainfall is high, and where little is known of irrigation, very good results have been obtained with the irrigation of farm crops.

Irrigation in the Blue valley is supplementary to the natural rainfall. It is seldom necessary to irrigate for longer than a short period during the latter part of July or the early part of August. Usually one irrigation is all that is applied, and occasionally there is a year when none is required. Notwithstanding this the farmers who have pumping plants have been highly pleased with their use. One farmer has been irrigating since 1896.

In 1919 the county agent of Washington county made a survey of irrigation in that county and found that of the farmers using irrigation, one irrigated a field of corn twice and obtained a yield of 70 bushels to the acre, and only 20 bushels from adjoining land which was not irrigated. Another farmer irrigated every other row of corn once and gathered 40 bushels per acre from the irrigated land, when the unirrigated portion yielded only 5 bushels per acre. Another farmer reported that potatoes which he irrigated in 1918 produced an average of 300 bushels per acre. Corn and potatoes have been the principal irrigated crops.

Irrigation water has been pumped directly from the Blue river without the use of dams or storage reservoirs.

CHAPTER IV.

REVIEW OF IRRIGATION LAWS.

A UNIFORM APPROPRIATION LAW.

Two sections of the General Statutes of 1915 (5562 and 5566), relating to the appropriation of water for irrigation, restrict the privileges conferred by such acts to limited portions of the state. Section 5562 says that, "*In all that portion of the state of Kansas situated west of the ninety-ninth meridian,* all natural waters, whether standing or running, and whether surface or subterranean, shall be devoted, first, to purposes of irrigation in aid of agriculture, subject to ordinary domestic uses; and secondly, to other industrial purposes; and may be diverted from natural beds, basins or channels for such purposes and uses." Section 5566 says that, "All waters flowing in subterranean channels and courses, or flowing or standing in subterranean sheets or lakes, *south of township 18 and west of the ninety-ninth meridian,* shall belong and be appurtenant to the lands under which they flow or stand, and shall be devoted, first, to the irrigating of such lands in the aid of agriculture, subject to ordinary domestic use." The result of these sections is that there are three degrees or stages of the right to the use of water for irrigation prevailing in as many different sections of the state. West of the ninety-ninth meridian and south of township 18 the right to the use of surface or running water must be acquired by appropriation, but it is apparently unnecessary to appropriate underground water, because such water is appurtenant to the land and the title to it is therefore vested in the land under which it stands. North of township 18 and west of the ninety-ninth meridian no distinction is made between surface and subterranean waters, and the right to either must be acquired by appropriation. East of the ninety-ninth meridian the right to the use of "running water flowing in a river or stream" may be acquired for irrigation, but there is no authority for the use of underground water for irrigation, nor any means by which the user of such water can perfect his title to it.

These laws were enacted at a time when it was popularly supposed that the practice of irrigation would be profitable and desirable only in the western third of the state. Since that time the value of irrigation in connection with intensive agriculture farther east in the state has been so amply demonstrated that to-day there are hundreds of irrigation pumping plants east of the ninety-ninth meridian. The owners of these plants have invested thousands of dollars in the development of underground water for irrigation of truck farms, gardens and orchards, but they have no means of perfecting their titles to the water until the above-mentioned laws are amended or new ones enacted. The irrigation commissioner, therefore, desires to recommend that these sections be amended by striking out the clauses which limit them to a restricted portion of the state, so that they will read:

"§ 5562. That all natural waters in the state of Kansas, whether standing or running, and whether surface or subterranean, shall be devoted, first, to purposes of irrigation in aid of agriculture, subject to ordinary domestic uses; and secondly, to other industrial purposes; and may be diverted from natural

beds, basins or channels for such purposes and uses: *Provided,* That no such diversion shall interfere with, diminish or divert any prior vested right of appropriation without the due legal condemnation of and compensation for the same; and natural lakes and ponds of surface water having no outlet shall be deemed parcel of the lands whereon the same may be situated, and only the proprietors of such lands shall be entitled to draw off or appropriate the same."

"§ 5566. All waters flowing in subterranean channels and courses, or flowing or standing in subterranean sheets or lakes, shall belong and be appurtenant to the lands under which they flow or stand, and shall be devoted, first, to the irrigating of such lands in aid of agriculture, subject to ordinary domestic use; second, subject to such use, may be devoted to other industrial purposes: *Provided, however,* That nothing herein contained shall in any way affect appropriations heretofore made."

THE RECORDING OF WATER RIGHTS.

In Kansas, water rights, or proof of the appropriation of water, is recorded only in the county in which such appropriation is made. Under the law, a person, company or corporation wishing to appropriate water must post a notice at the point of diversion, stating the amount of water the appropriator claims and the means by which he intends to divert such water. He must also, within ten days after he has posted such notice of appropriation, post a copy of it in the office of the county clerk, and a copy must be recorded by the register of deeds in a book to be kept for that purpose. The purpose of the law is to protect the appropriator who has spent money in the construction of works for the diversion of the water, against a subsequent appropriator who might deprive him of his water supply, since the law declares that between appropriators the first in time is the first in right. The intent of this procedure, then, is to enable the prior appropriator to establish his priority without the expense of a process at law and the examination of many witnesses. In most instances the acquired water right adds much to the value of the land to which it is appurtenant, and oftentimes the value of the water right is as great as that of the land itself. Considering this, it would seem that the record of appropriation would be preserved with utmost care, but an examination of the records of water rights in several counties shows that such is not the case.

In one county visited by the irrigation commissioner he found the notices of appropriation, sent to the register of deeds for record, tacked upon the wall around the room, and no record at all made of such appropriations. Although this officer would not think of tacking upon the wall a deed or mortgage sent him for record, he thought nothing of placing an equally valuable document where, if it fell on the floor or was blown out of the window, all record of it would be lost. In another county the register of deeds had acquired the practice of placing such notices of appropriation in a pigeonhole in the vault in lieu of recording them. While this method is manifestly safer than posting on the wall, such records could be taken from the vault, and in this manner all public record of them lost. In only a few instances was it found that such records were properly recorded as required by law.

Most states in which the right to appropriate water is recognized have long since abandoned this method of acquiring water rights, and the irrigation commissioner has been forced to the conclusion that some other method must be adopted properly to safeguard the appropriator of water in this state.

In the past the state has exercised no control over the amount of water which may be appropriated. The appropriator has only to name the amount of water he claims, regardless of the amount of land on which he expects to use such water. Ten cubic feet per second may be appropriated for ten acres of land, or the appropriator may claim one second foot for one thousand acres. No one with proper authority or knowledge checks the application; and since it is the duty of the register of deeds only to make a record of the appropriation, he is not interested in the amount. This method has resulted often in excessive appropriations being made by early appropriators, with the result that while the whole amount of water is not used, subsequent would-be appropriators are reluctant to file because of the fear that they cannot assert their right to the water.

The irrigation code needs modification in other ways to properly encourage, and at the same time regulate, irrigation development, but many of these things require time and study. The irrigation commissioner therefore wishes to recommend that, as a step in this direction, sections 5665, 5727 and 5728 of the General Statutes of 1915 be amended to read:

"§ 5665. *Record of appropriation of water to be kept by the irrigation commissioner.* That upon the passage and taking effect of this act, the register of deeds of any county wherein has been provided a record of appropriation of water and proof of the posting of notices thereof, as required by section 5665, article 1, chapter 57, General Statutes of 1915, shall within six months thereafter turn over to the irrigation commissioner a certified copy of all such records on file in said counties; and upon the passage of this act the register of deeds of any county in which water for irrigation is appropriated shall thereafter record only such records as have been officially issued by said irrigation commissioner."

"§ 5727. *Appropriation of water; water rights granted by the irrigation commissioner.* Any person, company or corporation desiring hereafter to appropriate water shall make application to the irrigation commissioner for a water right. Such application shall state, in cubic feet per second, the quantity of water desired, and shall be accompanied by a statement showing and describing the proposed point of diversion, the area to be irrigated, and giving a description of the proposed irrigation works, ditches and other appliances to be used in diverting and utilizing the water. Whenever application shall be made to the said irrigation commissioner for a water right under this section, it shall be the duty of the irrigation commissioner to examine the application without delay, and as soon as possible thereafter to issue the water right, if in his judgment the water required for beneficial use is available and remains unappropriated for irrigation purposes. The date of the appropriation, if granted, shall be coincident with that of the time the application was first received in the office of the irrigation commissioner. The water right shall be officially issued in duplicate, one copy of which shall be filed with the irrigation commissioner and the other recorded in the office of the register of deeds in the county where the diversion is made."

"§ 5728. *Time within which claimant must commence excavation or construction of works for such appropriation; rights of subsequent claimants.* Within six months after a water right has been granted the claimant must commence the excavation or construction of the works in which such claimant intends to divert the water, and must prosecute the work diligently and uninterruptedly to completion unless interrupted by stress of weather or other unavoidable circumstance. By compliance with the above, the claimant's right to the use of water relates back to the time the application was first received in the office of the irrigation commissioner. A failure to comply with the above conditions shall deprive the claimant of the right to the use of the water as against a subsequent claimant who complies therewith."

ARTESIAN WELLS.

The General Statutes contain a very extended act regulating in great detail the use of artesian wells, and storage reservoirs, ditches, etc., connected therewith. The first section of this act (section 5674) limits the application of it to artesian wells more than 400 feet deep. As far as is known, there are no wells in the state over 400 feet deep, and many of them are less than 200 feet deep. This act, therefore, is inapplicable to artesian wells in Kansas, and, it would appear, should either be amended by striking out the clause limiting it to wells more than 400 feet deep or should be repealed entirely.

DAM LAWS.

An examination of the laws relating to the building of dams reveals the fact that different requirements are made for the construction of dams by different interests, although no reason seems to exist why this should be. A dam constructed for the purpose of storing water for irrigation creates no greater menace to the public safety than one of like dimensions constructed for a milldam; nevertheless the requirements for the safety of the structure are quite different in the two cases.

Section 6248 of the General Statutes of 1915 requires that if a dam more than ten feet high be constructed for "irrigation purposes," the plans shall be drawn by a reputable engineer, who is required to give a bond for its safety as long as the structure is in use.

Section 6248 of the General Statutes of 1915 gives any person the right to construct a "milldam" on his own land across any stream, but puts no limit on the height of the dam and requires no guarantee for the safety of it.

Chapter 82 of the General Statutes of 1917 says that anyone wishing to construct a dam across a navigable stream shall submit his plans to the Public Utilities Commission for approval, after which he may proceed with the construction of it. No bond is required for the safety of the dam.

Sections 8841 to 8849 of the General Statutes of 1915: "Dams either of earth or masonry may be constructed by counties, townships, etc., as a part of the public highway." There appears to be no requirements regarding the qualifications of persons designing such dams, nor any provisions made to guarantee the safety of them.

The effect of these laws is to discriminate against irrigation projects. Much of the irrigation development along central and western Kansas streams depends upon the construction of dams for the storage of water. For the most part these dams are constructed by individual farmers for the irrigation of single farms. In such cases the farmer can ill afford to spend as much money in the construction of the dam as could an industrial enterprise, but notwithstanding this, a greater burden is imposed on him. The result of this is not only to throw an obstacle in the path of irrigation development, but to make it difficult for many farmers to develop at all and comply with the law.

Most Western states require that the plans for a dam be submitted to the state engineer, or some competent engineering board, for approval, after which the dam may be constructed, and no bond is required. The structure, of course, can be condemned and removed at any time it is deemed to be unsafe. Kansas has a law (sections 5656 to 5661, General Statutes of 1915) providing

for the condemnation and abatement of dams deemed unsafe. This, together with the requirement that the plans for any dam must be approved by some competent commission, should be sufficient without the requirement of a bond. In any event, we should have a uniform law for the designing and safety of dams, whether they are used in connection with irrigation projects or industrial enterprises.

FEB 1) 1925

Reprint from the Twenty-fourth Biennial Report of the State Board of Agriculture.

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REPORT *of the*

STATE IRRIGATION COMMISSIONER

TO THE

KANSAS STATE BOARD *of* AGRICULTURE

For the Biennium
July 1, 1922, to June 30, 1924

PRINTED BY KANSAS STATE PRINTING PLANT
B. P. WALKER, STATE PRINTER
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Kansas St. Board of Agri.
ft.
2-13-1925

LETTER OF TRANSMITTAL.

To the Kansas State Board of Agriculture:

I have the honor to transmit herewith a report of the work and finances of the Division of Irrigation for the biennium, July 1, 1922, to June 30, 1924.

Very respectfully,

GEO. S. KNAPP,
State Irrigation Commissioner.

REPORT OF THE COMMISSIONER.

CHAPTER I.

GENERAL REVIEW OF THE WORK OF THE DEPARTMENT.

APPROPRIATIONS AND EXPENDITURES.

The following table shows the appropriations, receipts and expenditures for the Division of Irrigation for the fiscal years ending June 30, 1923, and June 30, 1924:

For the fiscal year ending June 30, 1923:	
Appropriation for the year	$5,000.00
Fees received during year	145.80
Fee fund from previous year	7.32
Total	$5,153.12
For the fiscal year ending June 30, 1924:	
Appropriation for the year	$8,000.00
Fees received during year	120.00
Total	$8,120.00

Expenditures during the same years were:

	1923.	1924.
Salary of irrigation commissioner	$3,000.00	$3,000.00
Clerical help	299.75	533.71
Supplies, help and traveling expenses	1,852.89	4,156.21
Total	$5,152.64	$7,689.92

STATE IRRIGATION PLANTS.

When the Division of Irrigation of the Board of Agriculture was created by the legislature of 1919, the department inherited three state irrigation pumping plants, put in for experimental purposes under a law which was repealed in 1919. These pumping plants, located in Scott, Wichita and Wallace counties, were all on the high prairie where the depth to water was very great and where the plants could not be operated profitably. The 1921 legislature, therefore, authorized the sale of these pumping plants and provided for the disposition of the land on which they were located, either by authorizing its sale or returning it to persons who originally had donated it to the state. These sales were authorized by four acts, three relating to land and permanent improvements, and the fourth relating to personal property at all three farms. Two years ago the sale of this property was not completed, and a report of the partial sales appeared in the 1920-1922 biennial report. At this time the property authorized to be sold by three of the four acts has been disposed of and a complete statement of the receipts and disbursements follows:

Scott County Irrigation Farm—Chapter 278, Laws of 1921.

Receipts:		
Farm complete		$3,520.00
Disbursements:		
Scott Republican, advertising	$15.00	
Ellis Short, value of land	800.00	
To general revenue	2,705.00	
		$3,520.00

Improvements on Wallace County Farm—Chapter 279, Laws of 1921.

Receipts:		
Well casing	$25.00	
Buildings and fencing	1,310.00	
		$1,335.00
Disbursements:		
Advertising	$7.50	
Irrigation commissioner, expense account	4.90	
Edward Peterson, rental engine house	132.00	
To general revenue	1,190.60	
		$1,335.00

Personal Property in Scott, Wichita and Wallace Counties—Chapter 281, Laws of 1921.

Receipts:		
Auction, Scott county	$300.45	
Auction, Wichita county	194.35	
Auction, Wallace county	378.78	
Auction, Wallace county	5.00	
Auction, Wallace county	5.00	
Auction, Wallace county	5.00	
Belt, Wichita county	60.00	
		$948.58
Disbursements:		
Irrigation commissioner, expense account	$80.63	
Leoti Standard, advertising	13.00	
Irrigation commissioner, expense account	99.45	
Western Times, advertising	32.00	
Scott Republican, advertising	25.00	
Geo. Kelley, labor	19.00	
Grant Duvall, labor	25.00	
Leoti Standard, advertising	19.69	
To general revenue	634.81	
		$948.58

Included with the improvements on the Wallace county farm were a 100-hp. engine and a large irrigation pump which the department was unable to sell. These were transferred to the State Agricultural College by an act of the 1923 legislature (chapter 234, Laws of 1923).

While the Wichita county farm has been advertised repeatedly, no bids have ever been received for it, and the department has been unable to find anyone interested in the purchase of it. At this time it does not appear probable that the farm, consisting of 40 acres of land, and including a very expensive, but probably worthless, pumping plant, can be sold for enough to cover the $800 required by law upon the sale of the land to be paid to the person who donated the land to the state. The department is unable to recommend definitely what should be done with the Wichita county plant, but it seems that the legislature should make some provision for its disposition, either by turning it over to the county commissioners, returning it to the original owner, or allowing the dismantling of the plant.

INTERSTATE WATER CONTROVERSY.

The interstate water controversy existing between water users in Kansas and water users in Colorado on the Arkansas river has been referred to in two previous biennial reports. The 1923 legislature passed an act providing for the appointment of a commissioner by the governor, to meet with a commissioner from Colorado, for the purpose of drawing up a compact or treaty between the two states providing for "the future utilization and disposition of the waters of the Arkansas river and streams tributary thereto, and fixing and determining the rights of each of said states to the use, benefit and distribution of the waters of said stream." Similar legislation had been enacted by the Colorado legislature two years previously. The irrigation commissioner was appointed by Governor Davis to represent Kansas on this commission.

While progress on a matter of the magnitude of the Arkansas river problem has necessarily been slow, much time and careful study has been devoted to the subject and considerable progress has been made. In the first week in November, 1924, the two commissioners, meeting in Denver, made a preliminary draft of a proposed compact and it is now before the irrigation interests of the two states for their consideration.

In general, the proposed compact provides for the building of one or more reservoirs in Colorado to store the surplus waters of the stream for the benefit of the Kansas ditches. In the proposed compact Colorado is to purchase and place at the disposal of Kansas all lands, rights of way and easements necessary or essential for the construction and operation of such reservoirs, and it is contemplated that the necessary works will be constructed by the Kansas ditches who will participate in the additional water supply. The building of such reservoirs will make possible the storage of sufficient water so that 75,000 acre-feet of stored water can be released annually for the Kansas ditches at their demand.

GROWTH OF IRRIGATION PUMPING.

The department is pleased to report a very steady increase in the number of pumping plants in Kansas and the acreage being brought under pump irrigation. During the five years since this department was organized it has worked on 65 farm projects, has made topographic surveys and maps for 47 projects, covering a total of 3,640 acres. By far the larger part of this work has been done during the last biennium.

While the acreage under irrigation is not yet as large as that in the Garden City district, the greatest interest in pump irrigation is centered around the towns of Dodge City, Larned and Sterling. During the last two years a large number of new pumping plants have been installed in these localities. At Dodge City many of the pumping plants have been put in to aid in potato raising and truck growing, while at Larned the growing of sugar beets has been a prominent factor in the expansion of irrigation. Yields as high as 24 tons per acre have been reported there. At Sterling no special industry has contributed to the interest in pump irrigation, and the pumping plants installed there have been put in for the irrigation of general farm crops.

SPECIAL INVESTIGATIONS.

One of the duties of this department is to gather data, information and statistics concerning the water supplies of the state and the methods of developing the same. The department has, therefore, in addition to making the stream-flow measurements reported in Chapter II, endeavored to devote some time each year to a special study of some feature of the state's water resources or their development. One of these projects has been a special investigation of the artesian water in the Crooked creek valley of Meade county. This investigation revealed that there are over 270 artesian wells in the Crooked creek valley. These wells have all been located and measurements made of the pressure and volume of flow wherever it was possible to obtain them. In connection with this investigation, information from any source from which it could be obtained was secured concerning the logs of these wells, and considerable time has been given toward a study of the geology of the valley with particular reference to the probable amount of artesian water available for irrigation. The report of this investigation is partially prepared, but its completion requires more time than is available before the publication of this report, and a complete report covering this investigation must necessarily be delayed until the publication of a later biennial report.

Three months during the summer of 1924 were spent in making tests of irrigation pumping plants in use in the state of Kansas. These tests cover such matters of interest as the capacity of the plant, distance the water is lifted, the kinds of power used and the cost of pumping, and the flow of water in irrigation wells. This report is now in process of preparation and will be issued as a special report on irrigation pumping within the next few months.

FLOOD INVESTIGATIONS.

The Executive Department has called on the irrigation commissioner to make three special flood investigations. One, the disastrous Arkansas City flood in 1923; the other, two minor floods in Dickinson and Harvey counties. Comprehensive reports have been made on both the Arkansas City and Dickinson county flood situations. In both instances drainage districts were recommended as the solution of the problems there, but at this time, as far as is known, the recommendations have either not been carried out or have been acted on in only a limited way.

The Arkansas river, particularly, presents some very difficult problems from the standpoint of flood control. This stream rises in the Rocky Mountains in Colorado, and for about 120 miles from its source is a typical mountain stream, descending in this distance from an elevation of more than 10,000 feet to about 5,300 feet. As the river enters the plains region the gradient diminishes, the breadth increases, and the stream is unable at ordinary stages to carry the load of detritus collected in the more rapid portions above. This detritus is gradually deposited, forming low, sandy banks and bars, which block the course and cause the stream to continually shift its bed. Most of the mountain water is diverted from the stream for the irrigation of 500,000 acres of land in Colorado and 65,000 acres in Kansas. At normal times the stream in western Kansas is dry. In eastern Kansas it carries the flow of the Pawnee, Little Arkansas and other tributaries. This flow, which in dry times

is about 400 cubic feet per second and sometimes less than 100 cubic feet per second, meanders in a narrow stream over the wide sandy bed, the balance of the bed being dry bars of sand and silt. During dry times various forms of vegetation spring up on these bars. If such dry times are shortly followed by high water, this vegetation is usually destroyed. If, however, the period of drought is prolonged, the growth sometimes becomes so large that high water cannot destroy it, and the building of an island or obstruction is started. Each successive flood usually adds to it and builds it up. The flood waters, carrying, as they do, great quantities of sand and silt, as they enter the growth covering these islands, have their velocity reduced and much of the material hitherto held in suspension is deposited on the island. In this way flood after flood deposits successive layers of silt. Islands and other obstructions are thus increased in height until they present such formidable obstacles to stream flow that the river is compelled to leave its course and flow through the more open portions of the valley.

CHAPTER II.

STREAM-FLOW MEASUREMENTS.

The department is now maintaining three gaging stations on the Arkansas river, one on the Pawnee river, and five on the five principal irrigation canals taking water from the Arkansas river. The stations on the Arkansas river are located at Syracuse, Garden City and Larned. The station on the Pawnee river is also at Larned. These stations are all equipped with automatic recorders which make continuous records of the gage heights of the water passing the gages.

The gages on the Arkansas at Garden City and Larned, together with the one on the Pawnee river, were installed coöperatively by the irrigation commissioner and the United States Geological Survey. The irrigation commissioner furnished the well and shelter, while the United States Geological Survey furnished the recording instrument for the gage at Garden City and the one on the Pawnee at Larned. The United States Geological Survey furnished the entire installation on the Arkansas river at Larned. Gages at the coöperative stations are being maintained by the Irrigation Department, and discharge measurements, for the most part, are made by this department.

The greatly increased interest in irrigation in the Pawnee valley, together with the gradually increasing acreage being brought under irrigation, has brought about the necessity for some information concerning the flow of water on that stream. Most of the irrigation projects on the Pawnee involve the construction of channel reservoirs for the storage of water. In this connection information concerning the flood flow of the stream is necessary for the design of dams which will pass such floods without flooding adjacent land. As the acreage under irrigation expands, more storage projects will be built. The number of such projects and their extent will of course depend on the amount of water available, and therefore presents the necessity for authentic information regarding the available amount of water on that stream.

The season of 1922-'23 started in very dry and continued so until nearly the middle of May. Following this date the Arkansas river was subject to

a succession of very sharp, sudden floods, only one or two of which, however, reached the overflow stage. During the winter of 1922-'23 the river carried an unusual amount of water, which continued through the spring and up until almost the end of June. Following this the water supply dropped off very rapidly and the irrigation ditches suffered from a very deficient water supply during the whole months of July, August and September.

During the third week in March, 1924, an ice gorge was formed in the Arkansas river near Syracuse. With the breaking up of the gorge large quantities of ice were strewn all along the channel of the stream. This condition caused an abnormal flow to be recorded at Garden City and at Larned, due to the narrowing of the river channel by ice and the impounding of the water above the gorge. A part of the bridges at Hartland and at Kendall were torn away by the ice. The bridge at Deerfield was also somewhat damaged.

The series of river floods in the summer of 1923 furnished an excellent opportunity to secure information of value in flood forecasting. Information concerning eight of the principal floods is shown in the following table, which gives the date and time of the arrival of the floods, the gage height reached and the maximum flow of each of the three river stations. To properly interpret the information in this table it is necessary to study it in connection with the stage of the river immediately preceding the flood period, and local rainfall.

FLOOD PEAKS ON THE ARKANSAS RIVER IN 1923.

Syracuse.					Garden City.					Larned.			
Date.	Flood arrived.	Gage height.	Maximum flow.	Interval, hours.	Date.	Flood arrived.	Gage height.	Maximum flow.	Interval, hours.	Date.	Flood arrived.	Gage height.	Maximum flow.
May 22	5:30 p.	5.07	11,200	18	May 23	11:30 a.	7.15	14,900	41½	May 25	5:00 a.	6.24	2,990
June 9	1:00 a.	4.25	7,370	19	June 9	8:00 p.	5.80	7,260	52	June 11	Midnight	5.97	2,390
June 18	12:30 a.	5.65	14,300	10	June 18	10:30 a.	7.86	19,500	28½	June 19	3:00 p.	8.12	8,770
July 19	3:00 p.	3.90	5,760	12	July 20	3:00 a.	5.85	7,520	35	July 21	2:00 p.	6.54	3,780
July 27	2:00 p.	4.30	7,600	14	July 28	4:00 a.	5.10	3,790	56	July 30	Noon	5.90	2,250
Aug. 13	6:30 p.	3.85	5,530	16½	Aug. 14	11:00 a.	5.70	6,730	45	Aug. 16	8:00 a.	6.55	3,810
Aug. 18	2:00 a.	4.60	9,000	9	Aug. 18	11:00 a.	7.20	15,200	28	Aug. 19	3:00 p.	7.05	5,270
Aug. 23	10:00 a.	6.35	18,000	9	Aug. 23	9:00 p.	7.80	19,100	22	Aug. 24	7:00 p.	9.50	14,300

ARKANSAS RIVER AT SYRACUSE.

Location. At highway bridge half a mile south of Syracuse, in section 15, township 24 south, range 40 west.

Drainage area. Approximately 25,500 square miles.

Records available. June 20, 1921, to September 30, 1924.

Gage. Gurley automatic graphic water-stage register on downstream side of bridge pier, and staff gage on outside of gage well.

Discharge measurements. Made from bridge during high water and by wading at low stages.

Channel. Shifting.

Extremes of discharge. For the two-year period ending September 30, 1924 Maximum stage, 6.35 feet, August 23, 1923 (discharge 18,000 second-feet minimum stages, 0.93 feet, October 5 and 29, 1923 (discharge 4 second-feet).

Ice. Stage-discharge relation apparently affected but little by ice except during March, 1924, when an ice gorge occurred.

Diversions. There are court decrees for the diversion of approximately 12,825 second-feet from the Arkansas and its tributaries above this station in Colorado, and two small diversions above it in Kansas.

Accuracy. Rating curve fairly well defined between stages of 0.94 and 5.2 feet. Daily discharge ascertained by applying hourly gage heights to rating curve. Records fair.

DISCHARGE MEASUREMENTS of Arkansas river at Syracuse, 1922-'24.

Date.	Made by—	Gage height.	Discharge.
		Feet.	Sec. ft.
1922			
Nov. 20	Geo. S. Knapp	1.43	85.3
Dec. 7	Knapp and Schneider	1.50	83.2
1923.			
Jan. 18	Geo. S. Knapp	1.62	125
May 23	do	4.01	6,420
June 23	Knapp and Stambaugh	3.01	2,270
July 9	Vern W. Stambaugh	1.00	86.2
July 16	do	2.12	1,290
July 21	do	3.16	3,190
Sept. 7	do	2.74	1,520
Nov. 9	do	2.46	1,100
Dec. 3	do	2.16	644
1924.			
Mar. 24	Vern W. Stambaugh	2.69	1,290
Apr. 10	do	2.38	1,030
May 12	do	1.75	180
May 22	do	1.72	208
June 14	Stambaugh and Johnson	2.15	570
July 19	do	1.55	74.3
Aug. 26	do	1.13	8.3

DAILY GAGE HEIGHT, in feet, of Arkansas river at Syracuse, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.
1	.94	.96	1.44	1.59	1.57	1.54	1.30	1.32	1.83	1.40	2.60	3.22
2	.94	.96	1.45	1.56	1.55	1.54	1.30	1.25	1.76	1.33	2.52	3.07
3	.94	.97	1.48	1.49	1.54	1.55	1.18	1.12	1.70	1.30	3.67	2.90
4	.94	1.03	1.51	1.50	.....	1.52	1.12	1.05	1.69	1.23	3.33	2.89
5	.93	1.00	1.51	1.57	.....	1.53	1.08	1.03	1.64	1.18	3.17	2.91
6	.95	.98	1.52	1.61	.....	1.52	1.06	1.02	1.60	1.14	3.00	2.76
7	.95	.98	1.52	1.60	.....	1.50	1.03	1.00	1.53	1.08	2.92	2.70
8	.94	.98	1.47	1.60	.....	1.49	1.01	1.00	1.55	1.05	2.81	2.63
9	.94	.98	1.43	1.58	.....	1.49	1.00	.99	3.93	1.00	2.83	2.70
10	.94	1.00	1.45	1.58	1.59	1.48	1.00	.99	3.52	.94	2.92	2.77
11	.95	1.06	1.50	1.57	1.74	1.52	1.00	.98	3.00	.91	2.83	2.63
12	.95	1.12	.....	1.53	1.78	1.54	1.00	.99	2.77	1.28	2.42	2.62
13	.95	1.15	.....	1.51	1.79	1.54	1.01	1.02	2.54	1.95	2.43	2.45
14	.95	1.10	.....	1.47	.....	1.58	1.00	1.22	2.37	2.28	3.38	2.54
15	.96	1.11	.....	1.53	.....	1.45	1.00	1.60	2.30	2.87	2.99	2.69
16	.97	1.64	1.62	1.48	.....	1.57	1.00	1.52	2.28	2.25	2.58	2.52
17	.97	1.63	.....	1.43	1.82	1.56	.98	1.45	2.38	1.80	2.97	2.81
18	.97	1.58	.....	1.60	1.82	1.63	.97	1.40	4.75	2.56	4.10	2.96
19	.97	1.49	.....	1.57	1.82	1.63	.99	1.33	3.56	3.07	4.39	3.09
20	.97	1.44	.....	1.57	1.80	1.63	1.08	1.29	2.99	3.37	4.18	3.56
21	.96	1.44	.....	1.52	1.85	1.56	1.00	1.30	3.61	3.16	3.89	3.30
22	.96	1.45	.....	1.50	1.84	1.57	.99	2.07	3.35	3.01	3.26	3.13
23	.95	1.45	1.85	1.45	1.64	1.63	.99	4.26	3.12	2.91	4.60	2.98
24	.95	1.45	1.81	1.37	1.59	1.56	.98	3.35	2.64	2.66	5.22	2.84
25	.95	1.44	1.81	1.39	1.56	1.55	1.01	2.75	2.33	2.33	4.63	2.73
26	.95	1.46	1.83	1.58	1.56	1.51	1.09	2.44	2.05	2.05	4.34	2.60
27	.94	1.47	1.68	1.60	1.55	1.49	1.10	2.20	1.83	2.75	3.86	2.49
28	.94	1.43	1.67	1.54	1.54	1.44	1.04	2.05	1.67	3.30	3.60	2.40
29	.93	1.41	1.74	1.53	.....	1.37	1.31	1.97	1.57	3.06	3.53	2.38
30	.96	1.44	1.68	1.51	.....	1.32	1.35	1.94	1.45	2.83	3.64	2.20
31	.96	.....	1.61	1.52	.....	1.32	.....	2.00	.....	2.70	3.40	.....

DAILY GAGE HEIGHT, in feet, of Arkansas river at Syracuse, 1923-'24.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	2.23	2.84	2.19	2.26	2.80	2.18	2.50	2.39	2.01	1.72	1.21	1.11
2	2.19	2.74	2.19	2.27	2.79	.....	2.48	2.31	1.94	1.68	1.19	1.11
3	2.51	2.65	2.18	2.29	2.75	.....	2.48	2.20	1.98	1.63	1.19	1.11
4	2.28	2.59	2.20	2.30	2.58	.....	2.43	2.09	2.02	1.59	1.19	1.11
5	2.24	2.59	2.18	2.30	2.54	.....	2.32	1.97	1.93	1.53	1.21	1.09
6	3.17	2.55	2.17	2.34	2.50	.....	2.33	1.85	1.72	1.36	1.18	1.09
7	3.55	2.44	2.19	2.41	2.45	.....	2.28	1.80	1.64	1.33	1.15	1.14
8	3.40	2.42	2.24	2.57	2.42	2.10	2.30	1.76	1.59	1.30	1.13	1.10
9	3.06	2.43	2.23	.....	2.40	.....	2.38	1 73	1.54	1.32	1.14	1.06
10	3.57	2.47	2.22	.....	2.40	.....	2.38	1.72	1.49	1.68	1.24	1.06
11	3.85	2.47	2.22	.....	2.43	.....	2.44	1.71	2.35	1.43	1.44	1.08
12	3.65	2.45	2.24	2.86	2.53	.....	2.56	1.75	2.41	1.32	1.54	1.06
13	3.44	2.36	2.23	.....	2.56	.....	2.59	1.74	2.26	1.29	1.39	1.05
14	3.24	2.31	2.11	.....	2.53	.....	2.55	1.72	2.14	1.28	1.44	1.06
15	3.17	2.26	1.99	.....	2.52	2.12	2.57	1.68	2.15	1.27	1.39	1.07
16	2.96	2.25	1.96	.....	2.56	.....	2.55	1.65	2.22	1.26	1.39	1.07
17	2.93	2.23	2.06	.....	2.52	.....	2.61	1.61	2.60	1.30	1.36	1.10
18	2.91	2.21	2.27	.....	2.49	.....	2.66	1.58	2.63	1.48	1.31	1.13
19	2.88	2.21	2.28	2.18	2.51	.....	2.70	1.62	2.63	1.57	1.27	1.40
20	2.83	2.22	2.21	.....	2.50	.....	2.65	1.62	2.63	1.64	1.23	1.41
21	2.80	2.23	2.19	.....	2.48	.....	2.51	1.66	2.65	1.56	1.20	1.28
22	2.76	2.24	2.20	.....	2.46	.....	2.43	1.71	2.51	1.43	1.19	1.25
23	2.72	2.24	2.20	2.34	2.42	2.30	2.39	2.01	2.58	1.28	1.18	1.20
24	2.76	2.24	2.23	2.50	2.41	2.69	2.38	1.98	2.42	1.25	1.18	1.17
25	2.85	2.22	2.26	2.66	2.40	2.56	2.36	1.84	2.26	1.24	1.16	1.15
26	2.86	2.18	2.26	2.65	2.40	2.51	2.33	1.79	2.13	1.22	1.14	1.13
27	3.20	2.18	2.24	2.61	2.36	2.51	.....	1.77	1.96	1.22	1.13	1.12
28	3.16	2.19	2.24	2.65	2.28	2.50	.....	1.77	1.85	1.22	1.13	1.12
29	3.10	2.18	2.26	2 72	2.24	2.44	.....	1.75	1.79	1.22	1.12	1 13
30	2.99	2.18	2.26	2.77	.....	2.48	.....	1.87	1.75	1.21	1.11	1.14
31	2.91	.....	2.25	2.74	.....	2.61	.....	2.00	.....	1.21	1.10	.....

DAILY DISCHARGE, in second-feet, of Arkansas river at Syracuse, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	4	5	71	107	100	91	34	38	205	132	1,484	2,840
2	4	5	71	97	94	91	34	26	172	117	1,300	2,396
3	4	5	78	76	91	94	16	9	146	121	1,622	1,994
4	4	6	84	78	99	84	9	6	142	107	3,550	1,886
5	4	5	84	100	99	88	7	6	124	100	3,002	1,928
6	4	5	84	114	99	84	6	5	110	97	2,454	1,553
7	4	5	84	110	99	78	6	5	88	91	2,196	1,415
8	4	5	71	110	99	76	5	5	94	91	1,928	1,260
9	4	5	61	104	99	76	5	5	5,900	84	1,952	1,415
10	4	5	66	104	107	73	5	5	4,040	66	2,196	1,599
11	4	6	78	100	164	84	5	5	2,280	59	1,928	1,280
12	4	9	97	88	181	91	5	5	1,690	181	1,022	1,260
13	4	13	98	81	186	91	5	5	1,180	983	1,042	925
14	4	7	97	71	193	104	5	21	854	1,669	3,590	1,100
15	5	8	98	88	193	66	5	110	735	3,375	2,338	1,439
16	5	159	117	73	193	100	5	84	702	1,576	1,323	1,081
17	5	155	166	61	200	97	5	66	871	570	2,252	1,714
18	5	135	166	110	200	121	5	54	9,705	1,976	6,772	2,084
19	5	100	166	100	200	121	5	40	4,220	3,305	8,107	2,454
20	5	84	166	100	190	121	7	32	2,252	4,220	7,094	4,130
21	5	84	166	84	215	97	5	34	4,445	3,134	5,760	3,134
22	5	84	166	78	210	100	5	386	3,375	2,630	3,101	2,600
23	4	84	215	66	124	121	5	7,416	2,630	2,338	9,000	2,168
24	4	81	195	48	107	97	5	3,375	1,461	1,691	12,000	1,809
25	4	78	195	52	97	94	5	1,645	905	964	9,141	1,578
26	4	81	205	104	97	81	7	983	495	495	7,738	1,280
27	4	84	139	110	94	76	7	570	279	1,880	5,530	1,061
28	4	71	135	91	91	64	6	363	205	3,515	4,310	888
29	4	66	164	88	.....	48	36	286	177	2,720	3,995	719
30	5	71	139	81	.....	38	44	266	139	2,056	4,490	702
31	5	.....	114	84	.....	38	.....	305	.....	1,714	3,445	.....
Total	134	1,511	3,836	2,758	3,921	2,685	304	16,161	49,621	42,057	125,662	51,594
Mean	4.3	50.4	124	89	140	86.5	10.1	521	1,654	1,357	4,054	1,720
Max	5	159	215	114	215	121	44	7,416	9,705	4,220	12,000	4,130
Min	4	5	61	48	91	38	5	5	88	59	1,022	702
Acre-ft	265	2,990	7,600	5,460	7,760	5,320	602	32,000	98,200	83,300	249,000	102,000

DAILY DISCHARGE, in second-feet, of Arkansas river at Syracuse, 1923-'24.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.....	603	1,928	686	719	1,714	435	1,061	964	409	114	6	8
2.....	540	1,691	686	735	1,691	382	1,042	820	328	97	6	8
3.....	1,100	1,484	669	769	1,599	382	1,061	636	374	81	6	8
4.....	702	1,346	702	786	1,220	382	983	465	420	68	6	8
5.....	636	1,369	669	786	1,120	382	803	317	305	52	7	7
6.....	2,780	1,280	653	837	1,042	382	837	235	186	20	6	7
7.....	4,175	1,061	669	964	944	382	769	205	150	16	6	11
8.....	3,550	1,022	752	1,280	888	328	820	186	132	11	5	7
9.....	2,454	1,042	735	1,604	854	334	983	172	110	14	6	6
0.....	4,265	1,120	719	1,604	854	334	1,003	168	94	84	11	6
1.....	5,530	1,140	719	1,604	888	334	1,140	164	925	31	44	7
2.....	4,670	1,100	752	1,928	1,081	334	1,369	181	1,042	15	66	6
3.....	3,750	925	719	1,234	1,140	334	1,439	181	752	11	36	6
4.....	3,035	837	525	1,234	1,081	334	1,346	177	555	11	46	6
5.....	2,810	752	363	1,234	1,061	340	1,392	159	570	10	38	6
6.....	2,196	752	328	1,234	1,140	455	1,346	150	669	10	38	6
7.....	2,112	719	450	1,234	1,042	455	1,484	139	1,369	17	34	7
8.....	2,056	686	786	1,234	983	455	1,576	132	1,415	52	26	10
9.....	1,976	686	786	540	1,022	455	1,669	150	1,392	78	21	54
0.....	1,880	702	669	672	1,003	455	1,553	150	1,369	97	16	56
.....	1,809	719	636	672	964	455	1,240	172	1,392	68	14	31
.....	1,714	752	653	672	925	455	1,081	200	1,081	38	13	26
.....	1,622	752	653	803	837	570	1,003	450	1,200	13	13	18
.....	1,714	752	702	1,081	820	1,280	964	397	871	8	13	15
.....	1,928	719	735	1,415	803	1,042	925	266	587	7	11	13
.....	1,952	653	735	1,392	803	964	871	235	386	6	9	10
.....	2,936	653	702	1,300	735	983	918	225	235	6	9	9
.....	2,840	686	702	1,392	603	983	918	220	177	6	9	9
.....	2,660	669	735	1,553	525	888	918	210	146	6	9	10
.....	2,338	669	735	1,645	.....	983	918	279	128	6	8	11
.....	2,112	.....	702	1,576	.....	1,260	.....	409	.....	6	7	.....
tal.....	74,400	28,700	20,700	35,700	29,400	17,500	33,400	8,810	18,800	1,060	545	392
an.....	2,400	957	668	1,150	1,010	565	1,110	284	627	34.2	17.6	12.6
ax.....	5,530	1,928	786	1,928	1,714	1,280	1,669	964	1,415	114	66	56
n.....	603	653	328	540	525	328	803	132	94	6	5	6
re-ft....	147,000	56,800	41,000	70,700	58,200	34,700	66,100	17,400	37,200	2,100	1,080	776

MONTHLY DISCHARGE of Arkansas river at Syracuse, 1920-'24.

MONTH.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1920-'21.				
June	45,000	22	8,570	510.00
July	13,450	650	3,040	187.0
August	8,000	370	2,410	148.3
September	334	71	157	9.36
The period	45,000	22	3,540	855.00
1921-'22.				
October	192	71	96	5.89
November	204	68	116	6,92
December	568	95	326	20.06
January	401	106	233	14.35
February	507	150	366	20,34
March	441	68	185	11,36
April	641	41	177	10.51
May	453	34	120	8.01
June	103	5	23	1,39
July	158	5	20	1,25
August	501	3	115	7,14
September	5	4	5	27
The year	641	3	149	107,00
1922-'23.				
October	5	4	4	26
November	159	5	50	2,98
December	215	61	124	7,60
January	114	48	89	5,46
February	215	91	140	7,76
March	121	38	87	5,32
April	44	5	10	60
May	7,416	5	521	32,00
June	9,705	88	1,650	98,20
July	4,220	59	1,360	83,30
August	12,000	1,022	4,050	249,00
September	4,130	702	1,720	102,00
The year	12,000	4	9,817	594,00
1923-'24.				
October	5,530	603	2,400	147,00
November	1,928	653	957	56,80
December	786	328	668	41,00
January	1,928	540	1,150	70,70
February	1,714	525	1,010	58,20
March	1,280	328	565	34,70
April	1,669	803	1,110	66,10
May	964	132	284	17,40
June	1,415	94	627	37,20
July	114	6	34	2,10
August	66	5	18	1,08
September	56	6	13	77
The year	5,530	5	736	533,00

ARKANSAS RIVER AT GARDEN CITY.

Location. At highway bridge half a mile south of Garden City, in section 19, township 24 south, range 32 west.

Drainage area. Approximately 28,000 square miles.

Records available. June 20, 1922, to September 30, 1924. (Dry river during July, August and September, 1922.)

Gage. Stevens automatic graphic water-stage register on downstream side of bridge pier, and staff gage on outside of gage well.

Discharge measurements. Made from bridge during high water and by wading at low stages.

Channel. Shifting.

Extremes of discharge. Maximum stage, 7.86 feet, June 18, 1923 (discharge, 19,500 second-feet); minimum stage, 1.47 feet, October 1, 1922 (discharge, 0 second-feet).

Ice. Stage-discharge relation apparently affected but little by ice during 1922 and 1923. During March, 1924, affected by ice gorge.

Diversions. Between Syracuse station and this station five irrigation canals diverted water to the extent shown elsewhere in this report.

Accuracy. Rating curves well defined between stages of 2.59 and 7.03 feet. Daily discharge ascertained by applying hourly gage heights to rating curve. Records fair.

DISCHARGE MEASUREMENTS of Arkansas river at Garden City, 1922-'24.

DATE.	Made by—	Gage height.	Discharge.
1922.		Feet.	Sec.-ft.
Nov. 22	Knapp and Allen	2.59	4.6
1923			
Jan. 17	Geo. S. Knapp	2.69	5.3
Apr. 26	do	3.00	30.3
May 24	do	5.02	31.0
June 22	Knapp and Stambaugh	5.35	5,610
July 12	Vern W. Stambaugh	2.16	23.5
July 16	do	3.93	1,522
July 20	do	5.41	5,570
Aug. 24	do	7.03	14,050
Sept. 19	do	4.72	2,430
Oct. 9	do	5.05	3,550
Nov. 8	do	4.26	897
1924.			
Mar. 10	Vern W. Stambaugh	4.14	593
Mar. 29	do	4.95	1,970
May 13	do	3.46	47.1
June 2	do	3.54	39.3
July 17	do	2.95	1.1

DAILY GAGE HEIGHT, in feet, of Arkansas river at Garden City, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	1.47	2.60	2.56	2.91	2.69	2.74	2.74	3.15	2.72	2.88	3.70	4.[illegible]
2	1.47	2.61	2.57	2.84	2.72	2.73	2.73	3.05	2.65	2.76	3.62	4.[illegible]
3	1.48	2.59	2.60	2.80	2.71	2.75	2.76	2.95	2.60	2.64	3.53	4.[illegible]
4	1.49	2.58	2.61	2.75	2.69	2.74	2.86	2.90	2.59	2.55	4.52	4.[illegible]
5	1.48	2.51	2.62	2.72	2.71	2.78	2.85	2.87	2.56	2.65	4.30	4.[illegible]
6	1.49	2.57	2.56	2.75	2.77	2.79	2.78	2.85	2.61	2.47	4.12	4.[illegible]
7	1.51	2.60	2.52	2.76	2.75	2.74	2.74	2.83	2.60	2.35	4.16	4.[illegible]
8	1.53	2.61	2.48	2.70	2.75	2.73	2.74	2.81	2.97	2.28	4.20	4.[illegible]
9	1.56	2.62	2.53	2.67	2.72	2.70	2.74	2.80	3.42	2.25	5.25	4.[illegible]
10	1.60	2.58	2.58	2.67	2.75	2.70	2.74	2.80	5.30	2.22	5.29	3.[illegible]
11	1.62	2.61	2.59	2.67	2.78	2.72	2.74	2.78	4.56	2.19	4.18	4.[illegible]
12	1.65	2.64	2.61	2.67	2.86	2.70	2.74	2.76	3.94	2.16	4.48	4.[illegible]
13	1.69	2.61	2.61	2.67	2.77	2.70	2.76	2.79	3.61	2.15	4.18	3.[illegible]
14	1.77	2.58	2.62	2.66	2.71	2.70	2.75	3.05	3.42	2.62	4.75	3.[illegible]
15	2.05	2.56	2.62	2.65	2.72	2.76	2.74	3.38	3.26	3.06	4.93	3.[illegible]
16	2.32	2.54	2.62	2.67	2.80	2.77	2.74	3.12	3.18	3.78	4.48	4.[illegible]
17	2.43	2.56	2.62	2.68	2.87	2.93	2.74	3.02	3.00	3.63	4.30	4.[illegible]
18	2.52	2.53	2.63	2.66	2.90	2.81	2.73	2.98	5.30	3.35	5.38	4.[illegible]
19	2.51	2.52	2.63	2.67	2.95	2.83	2.73	2.95	5.48	4.26	6.38	4.[illegible]
20	2.52	2.52	2.63	2.67	2.88	2.97	2.76	2.91	4.62	5.21	5.95	4.[illegible]
21	2.53	2.49	2.64	2.66	3.14	2.97	2.78	3.24	4.41	4.99	5.53	5.[illegible]
22	2.53	2.48	2.64	2.65	2.88	2.91	2.78	3.31	5.30	4.26	4.98	4.[illegible]
23	2.52	2.49	2.67	2.65	2.79	2.83	2.78	4.67	4.52	4.02	5.45	4.[illegible]
24	2.53	2.51	2.73	2.66	2.75	2.78	2.78	5.09	4.50	3.94	7.23	4.[illegible]
25	2.55	2.52	2.76	2.76	2.76	2.79	2.80	4.41	4.03	3.83	6.04	4.[illegible]
26	2.58	2.52	2.79	2.82	2.77	2.77	2.95	3.87	3.84	3.68	5.95	4.[illegible]
27	2.58	2.54	2.85	2.78	2.76	2.78	3.03	3.38	3.65	3.53	5.56	4.[illegible]
28	2.58	2.58	3.07	2.78	2.75	2.76	2.97	3.20	3.45	4.57	5.14	4.[illegible]
29	2.59	2.57	3.05	2.81	.....	2.76	2.87	3.01	3.28	4.57	4.92	4.[illegible]
30	2.60	2.56	2.90	2.79	.....	2.75	2.83	2.88	3.07	3.97	5.14	4.[illegible]
31	2.60	.....	2.95	2.73	.....	2.74	.....	2.80	.....	3.78	5.03	

DAILY GAGE HEIGHT, in feet, of Arkansas river at Garden City, 1923-'24.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	4.19	4.60	4.12	.....	4.81	4.26	4.88	4.45	3.76	3.13	2.61	2.[illegible]
2	4.40	4.54	4.06	.....	4.84	4.18	4.77	4.39	3.57	3.13	2.57	2.[illegible]
3	4.38	4.49	4.07	.....	4.93	4.08	4.65	4.31	3.48	3.14	2.53	2.[illegible]
4	4.60	4.45	4.07	.....	4.82	3.98	4.59	4.23	3.44	3.10	.....	2.[illegible]
5	4.32	4.36	4.04	.....	4.64	4.01	4.52	4.09	3.41	3.09	.....	2.[illegible]
6	4.37	4.36	4.04	.....	4.63	4.10	4.44	3.94	3.39	3.07	.....	2.[illegible]
7	4.92	4.32	4.08	3.96	4.64	4.10	4.43	.....	.....	3.07	.....	2.[illegible]
8	5.02	4.26	4.09	3.78	4.64	4.08	4.40	.....	.....	3.03	.....	2.[illegible]
9	5.11	4.23	4.08	.....	4.70	4.11	4.44	.....	3.40	3.02	2.45	2.[illegible]
10	5.20	4.20	3.97	.....	4.77	4.17	4.50	.....	3.38	2.96	2.49	2.[illegible]
11	5.60	4.28	4.05	.....	4.78	4.21	4.54	.....	3.36	3.01	2.84	2.[illegible]
12	5.69	4.36	4.07	.....	4.77	4.21	4.58	3.59	3.36	3.18	2.93	2.[illegible]
13	5.54	4.42	3.99	.....	4.80	4.25	4.70	3.51	3.71	3.07	2.81	2.[illegible]
14	5.20	4.37	3.99	3.83	4.71	4.30	4.73	3.54	3.59	3.02	2.85	2.[illegible]
15	5.15	4.25	3.99	.....	4.62	4.27	4.59	3.49	3.46	3.00	2.72	2.[illegible]
16	5.23	4.19	3.98	.....	4.59	4.14	4.65	3.46	3.54	2.95	2.67	2.[illegible]
17	5.19	4.20	3.99	.....	4.68	3.91	4.65	3.39	3.43	2.96	2.72	2.[illegible]
18	5.07	4.20	4.07	4.37	4.71	3.82	4.74	3.38	3.42	3.10	2.74	2.[illegible]
19	5.10	4.20	4.48	4.35	4.77	.....	4.82	3.36	3.88	3.02	2.80	3.[illegible]
20	5.02	4.21	4.50	.....	4.76	.....	4.81	3.35	3.86	2.98	2.84	3.[illegible]
21	4.94	4.18	4.41	.....	4.77	.....	4.75	3.47	3.87	2.95	2.84	3.[illegible]
22	4.87	4.16	4.44	4.32	4.76	4.69	4.60	3.43	4.14	2.93	2.86	3.[illegible]
23	4.80	4.13	4.33	.....	4.74	4.71	4.45	3.37	3.90	2.87	2.88	3.[illegible]
24	4.80	4.09	4.30	.....	4.69	4.76	4.34	3.31	3.63	2.83	2.84	3.[illegible]
25	4.86	4.08	4.28	.....	4.68	4.88	4.33	3.40	3.78	2.80	2.83	3.[illegible]
26	4.90	4.07	4.30	.....	4.67	4.89	4.35	3.48	.....	2.77	2.77	3.[illegible]
27	4.83	4.07	4.24	4.42	4.71	4.95	4.33	3.72	.....	2.74	2.70	3.[illegible]
28	4.77	4.03	4.22	4.43	4.62	4.95	4.25	3.62	.....	2.69	2.62	3.[illegible]
29	4.72	4.04	4.19	4.48	4.45	4.88	4.32	3.63	3.16	2.78	2.60	3.[illegible]
30	4.67	4.07	4.12	4.63	.....	4.71	4.37	3.61	3.15	2.72	2.62	3.[illegible]
31	4.63	.....	.....	4.68	.....	4.86	.....	3.65	.....	2.65	2.58	

DAILY DISCHARGE, in second-feet, of Arkansas river at Garden City, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1.....	0	5	3	21	9.5	12	12	80	14	120	528	2,220
2.....	0	5.5	3.5	17	11	12	12	44	10	80	440	1,740
3.....	0	4.5	5	15	10	12	13	27	8	46	353	1,620
4.....	0	4	5.5	12	9.5	12	18	22	7.5	36	1,970	1,520
5.....	0	.5	6	11	10	14	18	20	5.5	85	1,520	1,410
6.....	0	3.5	3	12	14	14	14	19	8	36	1,150	1,320
7.....	0	5	1	13	12	12	12	18	7.5	25	1,200	1,180
8.....	0	5.5	0	10	12	12	12	18	32	22	1,320	1,060
9.....	0	6	1.5	8.5	11	10	12	17	260	23	4,710	928
10.....	0	4	4	8.5	12	10	12	17	4,960	24	4,710	824
11.....	0	5.5	4.5	8.5	14	11	12	16	2,090	25	1,220	992
12.....	0	7	5.5	8.5	18	10	12	16	838	24	1,850	944
13.....	0	5.5	5.5	8.5	14	10	13	17	420	17	1,220	852
14.....	0	4	6	8	10	10	12	55	253	110	2,520	852
15.....	0	3	6	7.5	11	13	12	246	140	353	3,180	838
16.....	0	2	6	8.5	15	14	12	90	100	1,220	1,850	1,180
17.....	0	3	6	9	18	23	12	48	34	838	1,410	1,130
18.....	1	1.5	6.5	8	20	16	12	40	4,710	380	5,200	2,220
19.....	.5	1	6.5	8.5	25	16	12	34	5,700	1,620	10,500	2,220
20.....	1	1	6.5	8.5	19	27	13	28	2,220	4,480	8,060	3,000
21.....	1.5	0	7	8	70	27	14	163	1,620	3,580	5,960	3,790
22.....	1.5	0	7	7.5	19	21	14	209	4,710	1,410	3,370	2,840
23.....	1	0	8.5	7.5	14	16	14	2,520	1,970	1,010	5,450	2,360
24.....	1.5	.5	12	8	12	14	14	4,240	2,090	880	15,500	2,090
25.....	2.5	1	13	13	13	14	15	1,850	1,130	726	8,580	1,970
26.....	4	1	14	16	14	14	25	824	880	516	8,060	1,850
27.....	4	2	18	14	13	14	36	260	670	362	5,960	1,620
28.....	4	4	44	14	12	13	27	140	470	2,090	4,020	1,410
29.....	4.5	3.5	40	16	.....	13	19	48	344	2,090	3,000	1,220
30.....	5	3	20	14	.....	12	17	25	209	912	4,020	1,130
31.....	5	.....	25	12	.....	12	.....	18	.....	642	3,580	.....
Total.....	37	92	300	341.5	442	440	452	11,169	35,910	23,782	122,411	48,330
Mean.....	1.19	3.07	9.68	11.0	15.8	14.2	15.1	360	1,200	767	3,950	1,610
Max.....	5	7	44	21	70	27	36	4,240	5,700	4,480	15,500	3,790
Min.....	0	0	0	7.5	9.5	10	12	16	5.5	17	353	824
Acre-ft....	73.2	183	595	676	878	873	898	22.100	71,400	47,200	243,000	95,800

DAILY DISCHARGE, in second-feet, of Arkansas river at Garden City, 1923-'24.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	1,200	1,620	675	597	1,740	763	1,830	1,020	290
2	1,620	1,470	600	571	1,810	663	1,590	935	125
3	1,580	1,370	613	544	2,010	538	1,360	815	80
4	2,090	1,280	613	518	1,760	414	1,260	713	69
5	1,450	1,090	575	491	1,360	450	1,140	538	63
6	1,560	1,080	575	465	1,360	550	1,010	356	57
7	3,070	1,010	625	438	1,360	550	995	308	58
8	3,450	896	638	240	1,360	525	950	261	58
9	3,840	845	625	248	1,550	563	1,010	214	59
10	4,200	800	488	256	1,650	638	1,100	167	53
11	6,110	920	575	265	1,650	688	1,170	120	50
12	6,520	1,040	600	273	1,650	688	1,240	73	50
13	5,750	1,140	500	281	1,650	738	1,450	57	230
14	4,060	1,060	500	290	1,550	800	1,510	65	120
15	3,790	875	500	459	1,360	763	1,260	57	67
16	4,110	775	488	628	1,275	600	1,360	52	95
17	3,880	788	500	797	1,450	322	1,360	41	61
18	3,330	788	600	965	1,550	230	1,530	41	57
19	3,410	788	1,190	935	1,650	530	1,700	38	391
20	3,110	800	1,190	920	1,650	830	1,670	38	368
21	2,800	763	1,070	905	1,650	1,130	1,550	61	379
22	2,550	738	1,120	890	1,650	1,430	1,280	53	700
23	2,310	700	935	920	1,550	1,470	1,020	45	402
24	2,280	650	890	950	1,450	1,570	860	35	134
25	2,420	638	860	980	1,450	1,830	845	52	270
26	2,520	625	890	1,010	1,450	1,850	875	67	206
27	2,310	625	800	1,040	1,450	1,990	845	220	143
28	2,120	563	775	1,060	1,360	1,990	738	142	79
29	1,970	575	738	1,140	1,040	1,830	830	151	16
30	1,830	613	650	1,380	.....	1,470	905	142	16
31	1,710	.....	624	1,470	.....	1,780	.....	185	.....
Total	93,000	26,900	22,000	21,900	44,400	30,200	36,200	7,060	4,750
Mean	3,000	898	710	707	1,530	974	1,210	228	158
Max	6,520	1,620	1,190	1,470	2,010	1,990	1,830	1,020	700
Min.	1,200	563	488	240	1,040	230	738	35	16
Acre-ft.	184,000	53,400	43,700	43,500	88,200	59,900	71,900	14,000	9,410

MONTHLY DISCHARGE of Arkansas river at Garden City, 1922-'24.

MONTH.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1922-'23.				
October	5	0	1.2	73
November	7	0	3.1	183
December	44	0	9.7	595
January	21	7.5	11	676
February	70	9.5	16	878
March	27	10	14	873
April	36	12	15	898
May	4,240	16	360	22,100
June	5,700	5.5	1,200	71,400
July	4,480	17	767	47,200
August	15,500	353	3,950	243,000
September	3,790	824	1,610	95,800
The year	15,500	0	663	484,000
1923-'24.				
October	6,520	1,200	3,000	184,000
November	1,620	563	898	53,400
December	1,190	488	710	43,700
January	1,470	240	707	43,500
February	2,010	1,040	1,530	88,200
March	1,990	230	974	59,900
April	1,830	738	1,210	71,900
May	1,020	35	228	14,000
June	700	16	158	9,410
July	13	0	3.7	224
August	0	0	0	0
September	4	0	.5	30
The year	6,520	0	785	568,000

ARKANSAS RIVER AT LARNED.

Location. At highway bridge half a mile south of Larned in section 5, township 22 south, range 16 west.

Drainage area. Approximately 30,000 square miles.

Records available. June 20, 1922, to September 30, 1924. (Dry river during July, August and September, 1922.)

Gage. Stevens automatic graphic water-stage register on downstream side of bridge pier, and staff gage on outside of gage well.

Discharge measurements. Made from bridge during high water and by wading at low stages.

Channel. Shifting.

Extremes of discharge. Maximum stage, 9.50 feet, August 24, 1923 (discharge, 14,300 second-feet); minimum stage, 0.78 feet, November 15, 1922 (discharge, 0 second-feet).

Ice. Stage-discharge relation affected but little during winter months of 1922 and 1923. During March, 1924, somewhat affected by ice gorge in river.

Accuracy. Rating curve fairly well defined between stages of 3.42 and 8.39 feet. Daily discharge ascertained by applying hourly gage heights to rating curve. Records fair.

DISCHARGE MEASUREMENTS of Arkansas river at Larned, 1923-'24.

DATE.	Made by—	Gage height.	Discharge.
1923.		Feet.	Sec.-ft.
June 4	Geo. S. Knapp	4.40	484
June 25	Knapp and Stambaugh	5.71	1,900
June 26	do	6.05	2,520
July 11	Vern W. Stambaugh	3.43	103
July 18	do	3.64	235
July 19	do	4.60	887
Aug. 20	do	7.00	5,130
Aug. 20	do	8.39	9,740
Oct. 1	do	5.15	1,270
Nov. 19	do	5.05	968
Nov. 30	do	4.77	662
1924.			
Mar. 4	Vern W. Stambaugh	4.92	695
Mar. 31	do	5.72	1,940
May 9	do	4.69	480
June 21	Stambaugh and Johnson	3.68	13.7
July 21	do	3.57	6.5

DAILY GAGE HEIGHT, in feet, of Arkansas river at Larned, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.
1	1.17	.95	1.05	.....	.96	3.00	2.90	3.05	5.11	4.45	5.02	6.7
2	1.16	.94	1.06	.....	.96	2.97	2.85	3.06	5.08	4.32	4.81	6.2
3	1.15	.92	1.06	.....	.96	3.02	2.80	3.21	4.73	4.19	4.70	5.9
4	1.15	.91	1.06	.....	.96	.....	2.83	3.25	4.53	4.06	4.61	5.6
5	1.14	.95	.....	.....	.96	.....	2.85	3.38	4.79	3.95	4.51	5.4
6	1.13	.94	.....	.....	.97	.....	2.83	3.38	4.55	3.82	5.33	5.3
7	1.12	.94	.....	.....	.98	.....	2.78	3.37	4.34	3.70	5.49	5.1
8	1.12	.94	.....	.....	.99	.....	2.74	3.31	4.39	3.58	5.16	5.2
9	1.11	.90	.....	.....	1.02	.....	2.74	3.22	4.88	3.47	4.99	5.1
10	1.10	.86	.....	.....	1.03	.....	2.68	3.19	5.01	3.35	5.16	5.0
11	1.09	.84	.....	.....	1.02	2.96	2.66	3.08	5.00	3.25	5.07	5.0
12	1.09	.82	.....	.....	1.02	3.00	2.65	2.98	6.55	3.32	5.90	4.9
13	1.08	.82	.....	.....	1.01	2.97	2.67	3.00	6.02	3.37	5.38	4.8
14	1.07	.79	.....	.....	1.01	2.93	2.65	3.11	5.47	3.38	5.25	4.9
15	1.06	.78	.....	.....	1.00	2.85	2.62	3.27	5.05	3.42	5.21	4.8
16	1.06	.79	.....	.....	1.00	2.85	2.62	3.37	4.78	3.53	5.83	4.8
17	1.05	.82	.....	.....	.....	2.86	2.62	3.47	4.56	3.55	6.89	4.9
18	1.04	.87	.....	.....	.....	2.76	2.64	3.52	4.47	3.66	5.40	5.0
19	1.03	.91	.....	.96	.....	2.65	2.66	3.54	5.59	4.54	5.81	5.1
20	1.03	.94	.....	.96	.....	2.74	2.77	3.49	7.31	4.29	6.89	5.0
21	1.02	.96	.....	.96	.....	2.84	2.81	3.48	6.54	4.86	7.21	5.7
22	1.01	.99	.....	.96	2.88	2.78	2.74	3.58	6.09	6.29	6.55	6.4
23	1.00	1.01	.....	.96	2.88	2.98	2.70	3.19	6.47	5.82	6.27	6.1
24	1.00	1.03	.....	.96	2.93	3.00	2.64	3.18	6.42	5.33	6.31	5.8
25	.99	1.04	.....	.96	2.96	3.02	2.66	5.59	5.95	5.13	8.98	5.6
26	.99	1.05	.....	.96	3.03	3.02	2.94	5.90	5.95	5.13	7.88	5.3
27	.98	1.05	.....	.96	3.06	3.02	2.99	5.50	5.38	4.78	7.84	5.4
28	.98	1.05	.....	.96	3.03	3.04	3.04	5.11	4.96	4.61	7.27	5.4
29	.97	1.04	.....	.96	.....	2.99	3.10	4.71	4.72	4.50	6.73	5.3
30	.98	1.05	.....	.96	.....	2.93	3.09	4.62	4.58	5.12	6.39	5.2
31	.97	.....	.....	.96	.....	2.90	.....	4.65	.....	5.46	6.12	.....

DAILY GAGE HEIGHT, in feet, of Arkansas river at Larned for 1923-'24.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	5.15	5.74	4.70	.....	5.98	.....	.....	5.63	4.27	3.68	2.52	.....
2	5.10	5.79	4.68	.....	5.76	.....	5.87	5.26	4.21	3.74	2.46	.....
3	5.03	5.78	4.73	.....	5.88	5.05	5.73	5.13	4.14	3.69	2.40	.....
4	4.98	5.73	4.75	.....	.....	4.92	5.62	5.12	4.11	3.63	2.34	.....
5	4.94	5.62	4.72	.....	.....	.....	5.51	5.07	4.06	3.56	2.28	.....
6	4.99	5.54	4.71	.....	.....	.....	5.42	4.95	.....	3.52	2.43	.....
7	5.03	5.48	4.73	.....	.....	4.78	5.33	4.85	3.93	3.50	2.31	.....
8	5.84	5.46	4.73	.....	.....	.....	5.27	4.75	3.93	3.45	2.26	.....
9	6.25	5.35	4.71	.....	.....	.....	5.21	4.68	3.93	3.41	2.21	.....
10	6.10	5.26	4.69	.....	.....	.....	5.21	4.60	3.91	3.23	2.19	.....
11	6.68	5.24	4.69	.....	.....	.....	5.17	4.53	3.89	3.09	2.22	.....
12	7.19	5.25	4.71	.....	5.75	.....	5.24	4.48	3.87	2.98	2.17	.....
13	7.17	5.24	4.62	.....	.....	.....	5.36	4.44	3.86	3.05	2.13	.....
14	7.01	5.25	4.49	.....	.....	.....	5.42	4.38	3.85	3.50	2.35	.....
15	6.60	5.19	4.63	.....	.....	.....	5.40	4.34	3.82	3.57	4.00	.....
16	6.27	5.16	4.56	.....	.....	.....	5.43	4.29	3.80	3.53	3.72	.....
17	6.26	5.13	4.53	.....	.....	.....	5.44	4.23	3.77	3.51	3.61	.....
18	6.25	5.09	4.67	.....	5.30	.....	5.43	4.20	3.80	3.70	3.59	.....
19	6.10	5.05	4.60	.....	.....	.....	5.31	4.17	3.78	3.76	3.39	.....
20	5.95	5.02	4.59	.....	.....	4.60	5.40	4.12	3.72	3.77	3.17	.....
21	5.87	4.98	4.85	5.25	.....	.....	5.48	4.08	3.69	3.64	3.07	.....
22	5.80	4.95	4.87	5.26	.....	.....	5.45	4.04	3.66	3.54	3.00	.....
23	5.75	4.94	4.85	5.30	5.20	.....	5.37	4.00	3.61	3.40	2.89	.....
24	5.69	4.92	5.05	5.39	.....	.....	5.24	3.98	3.77	3.14	2.79	.....
25	5.64	4.88	5.11	.....	.....	.....	5.07	3.97	3.89	2.97	2.68	.....
26	5.61	4.87	5.05	.....	.....	.....	4.99	3.99	3.94	2.86	2.57	.....
27	5.83	4.87	5.09	5.51	.....	6.00	4.90	4.16	4.04	2.77	2.46	.....
28	5.81	4.84	5.11	.....	.....	.....	4.92	4.12	3.92	2.70	2.36	.....
29	6.13	4.81	5.08	5.48	5.27	.....	5.89	5.15	3.76	2.77	2.25	.....
30	5.97	4.77	5.09	5.47	.....	.....	6.06	4.14	3.72	2.65	2.14	.....
31	5.82	.....	.....	5.62	.....	5.74	.....	4.20	.....	2.58	2.04	.....

DAILY DISCHARGE, in second-feet, of Arkansas river at Larned, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	0	0	0	0	0	18	10	25	1,080	527	1,190	4,520
2	0	0	0	0	0	16	6	26	1,080	464	970	3,270
3	0	0	0	0	0	21	2	52	746	384	830	2,560
4	0	0	0	0	0	20	4.4	59	595	334	746	2,060
5	0	0	0	0	0	20	6	84	786	277	668	1,730
6	0	0	0	0	0	19	4.4	84	595	223	527	1,510
7	0	0	0	0	0	18	1.5	82	364	184	1,730	1,310
8	0	0	0	0	0	18	.3	70	494	145	1,310	1,440
9	0	0	0	0	0	17	.3	54	874	114	1,080	1,310
0	0	0	0	0	0	16	0	48	970	84	1,250	1,140
.....	0	0	0	0	0	15	0	29	970	66	1,140	1,080
.....	0	0	0	0	0	18	0	16	3,950	86	2,450	970
.....	0	0	0	0	0	16	0	18	2,450	106	1,510	1,020
.....	0	0	0	0	0	12	0	34	1,510	117	1,310	1,020
.....	0	0	0	0	0	6	0	63	1,020	134	1,250	970
.....	0	0	0	0	0	6	0	82	786	174	2,160	1,020
.....	0	0	0	0	0	6.8	0	106	595	190	4,820	1,020
.....	0	0	0	0	0	.9	0	120	527	244	1,440	1,080
.....	0	0	0	0	0	0	0	125	1,730	830	2,060	1,310
.....	0	0	0	0	0	.3	1.2	111	6,060	630	4,820	1,980
.....	0	0	0	0	0	5.2	2.8	109	3,670	1,140	5,750	2,250
.....	0	0	0	0	8.4	1.5	.3	136	2,660	3,950	3,950	3,950
.....	0	0	0	0	8.4	16	0	48	3,540	2,660	3,140	3,020
.....	0	0	0	0	12	18	0	46	3,400	1,730	3,140	2,450
.....	0	0	0	0	15	21	0	1,730	2,350	1,440	12,200	2,060
.....	0	0	0	0	22	21	13	2,250	2,350	1,440	8,010	1,890
.....	0	0	0	0	26	21	17	1,580	1,440	970	7,670	1,730
.....	0	0	0	0	22	24	24	1,080	922	830	6,060	1,580
.....	0	0	0	0	.....	17	32	706	706	706	4,520	1,440
.....	0	0	0	0	.....	12	31	630	630	1,380	3,670	1,360
.....	0	.....	0	0	.....	10	.....	668	.....	1,810	3,020	.....
al.....	0	0	0	0	113.8	430.7	156.2	10,271	48,850	23,369	94,391	54,050
an.....	0	0	0	0	4.06	13.9	5.21	331	1,630	754	3,040	1,800
x.....	0	0	0	0	26	24	32	2,250	6,060	3,950	12,200	4,520
1.....	0	0	0	0	0	0	0	16	364	66	527	970
e-ft....	0	0	0	0	225	855	310	20,400	97,000	46,400	187,000	107,000

DAILY DISCHARGE, in second-feet, of Arkansas river at Larned, 1923-'24.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	1,270	1,990	616	924	2,040	955	2,060	1,420	187	14	0	0
2	1,210	2,060	602	930	1,690	880	2,160	981	164	19	0	0
3	1,120	2,030	638	936	1,870	804	1,910	856	139	15	0	0
4	1,070	1,940	653	943	1,840	668	1,720	839	128	10	0	0
5	1,030	1,760	623	949	1,820	670	1,540	786	112	4	0	0
6	1,070	1,630	616	955	1,790	643	1,400	683	94	2	0	0
7	1,110	1,540	630	962	1,770	616	1,290	602	76	2	0	0
8	2,330	1,510	630	968	1,740	612	1,200	527	74	0	0	0
9	3,240	1,350	616	974	1,720	608	1,120	476	72	0	0	0
10	2,870	1,240	602	981	1,690	605	1,110	429	66	0	0	0
11	4,430	1,210	602	988	1,660	601	1,070	389	61	0	0	0
12	5,970	1,210	616	995	1,640	597	1,140	359	55	0	0	0
13	5,910	1,200	553	1,000	1,540	594	1,260	334	52	0	0	0
14	5,410	1,210	464	1,010	1,450	590	1,320	303	48	2	12	0
15	4,150	1,140	553	1,010	1,360	586	1,290	282	41	6	64	0
16	3,240	1,100	507	1,020	1,260	582	1,320	256	36	3	18	0
17	3,220	1,070	488	1,020	1,160	579	1,320	227	29	2	9	0
18	3,170	1,010	581	1,030	1,070	575	1,300	210	32	16	8	0
19	2,800	970	534	1,040	1,050	571	1,150	196	28	24	0	0
20	2,470	931	527	1,040	1,020	567	1,250	177	18	25	0	0
21	2,290	893	714	1,050	1,000	827	1,340	161	15	12	0	0
22	2,160	856	722	1,060	975	1,090	1,290	145	12	4	0	0
23	2,060	839	706	1,100	951	1,350	1,180	131	8	0	0	0
24	1,940	821	874	1,200	964	1,610	1,040	122	24	0	0	0
25	1,860	778	931	1,250	977	1,870	856	117	43	0	0	0
26	1,810	770	874	1,290	990	2,130	778	120	52	0	0	0
27	2,170	762	912	1,340	1,000	2,390	698	168	70	0	0	0
28	2,140	730	931	1,320	1,020	2,280	706	152	48	0	0	0
29	2,780	706	903	1,300	1,030	2,180	1,840	158	22	0	0	0
30	2,430	668	912	1,290	.....	2,070	2,120	152	17	0	0	0
31	2,140	.....	918	1,480	.....	1,960	.....	168	.....	0	0	.....
Total	80,900	35,900	21,000	33,400	40,100	32,700	39,800	11,900	1,820	160	111	0
Mean	2,610	1,200	679	1,080	1,380	1,050	1,330	385	60.8	5.2	3.6	0
Max	5,970	2,060	931	1,480	2,040	2,390	2,160	1,420	187	25	64	0
Min	1,030	668	464	924	951	567	698	117	8	0	0	0
Acre-ft	160,000	71,000	41,700	66,000	79,400	64,700	78,800	23,600	3,610	317	220	0

MONTHLY DISCHARGE of Arkansas river at Larned, 1922-'24.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1922-'23.				
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0
January	0	0	0	0
February	26	0	4.1	225
March	24	0	14	855
April	32	0	5.2	310
May	2,250	16	331	20,400
June	6,060	364	1,630	97,000
July	3,950	66	754	46,400
August	12,200	527	3,040	187,000
September	4,520	970	1,800	107,000
The year	12,200	0	632	459,000
1923-'24.				
October	5,970	1,030	2,610	160,000
November	2,060	668	1,200	71,100
December	931	464	679	41,700
January	1,480	924	1,080	66,000
February	2,040	951	1,380	79,400
March	2,390	567	1,050	64,700
April	2,160	698	1,330	78,800
May	1,420	117	385	23,600
June	187	8	61	3,610
July	25	0	5.2	317
August	64	0	3.6	220
September	0	0	0	0
The year	5,970	0	815	589,000

PAWNEE RIVER AT LARNED.

Location. At highway bridge 2½ miles west of Larned, in section 1, township 22 south, range 17 west.

Drainage area. Approximately 2,300 square miles.

Records available. April, 1924, to September 30, 1924.

Gage. Automatic water-stage recorder manufactured by United States Geological Survey, on downstream side of bridge pier, and staff gage on outside of gage well.

Discharge measurements. Made from bridge at gage.

Channel. Nearly permanent.

Accuracy. Rating curve not well defined, only three low-water ratings made. Back-water effect from newly constructed dam one-half mile downstream. Daily discharge not ascertained.

DAILY GAGE HEIGHT, in feet, of Pawnee river at Larned, 1923-'24.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	.....	.....	.....	.....	.....	.....	3.08	2.90	1.28	1.04	.96
2	.....	.....	.....	.....	.....	.....	.....	3.59	2.92	1.24	1.01	.88
3	.....	.....	.....	.....	.....	.....	.....	2.75	2.75	1.19	.98	.81
4	.....	.....	.....	.....	.....	.....	.....	2.16	2.52	1.22	.92	.77
5	.....	.....	.....	.....	.....	.....	.....	1.94	2.29	1.26	.85	.73
6	.....	.....	.....	.....	.....	.....	.....	1.79	2.16	1.28	.96	.67
7	.....	.....	.....	.....	.....	.....	.....	1.59	2.00	1.26	.98	.64
8	.....	.....	.....	.....	.....	.....	1.58	1.33	2.13	1.28	1.02	.63
9	.....	.....	.....	.....	.....	.....	1.56	1.27	2.19	1.29	1.06	.63
10	.....	.....	.....	.....	.....	.....	1.52	1.34	2.26	1.30	1.10	.62
11	.....	.....	.....	.....	.....	.....	1.50	1.49	2.30	1.35	1.17	.60
12	.....	.....	.....	.....	.....	.....	1.48	1.45	2.32	1.35	1.20	.56
13	.....	.....	.....	.....	.....	.....	1.43	1.40	2.36	1.32	1.21	.56
14	.....	.....	.....	.....	.....	.....	1.40	1.40	2.36	1.29	1.22	.58
15	.....	.....	.....	.....	.....	.....	1.40	1.37	2.32	1.31	1.23	.60
16	.....	.....	.....	.....	.....	.....	1.36	1.89	2.28	1.39	2.47	.61
17	.....	.....	.....	.....	.....	.....	1.32	2.05	2.22	1.47	3.90	.59
18	.....	.....	.....	.....	.....	.....	1.31	1.90	2.16	1.60	2.94	.57
19	.....	.....	.....	.....	.....	.....	1.31	1.81	2.06	1.65	2.75	.72
20	.....	.....	.....	.....	.....	.....	1.25	2.01	1.93	1.68	2.55	.75
21	.....	.....	.....	.....	.....	.....	.88	2.93	1.85	1.67	2.40	.74
22	.....	.....	.....	.....	.....	.....	1.19	3.32	1.78	1.61	1.98	.73
23	.....	.....	.....	.....	.....	.....	1.65	2.99	1.72	1.55	1.75	.73
24	.....	.....	.....	.....	.....	.....	1.69	2.79	1.65	1.48	1.46	.72
25	.....	.....	.....	.....	.....	.....	1.62	2.44	1.58	1.43	1.33	.72
26	.....	.....	.....	.....	.....	.....	1.52	2.16	1.52	1.37	1.22	.76
27	.....	.....	.....	.....	.....	.....	1.37	2.31	1.47	1.32	1.14	1.46
28	.....	.....	.....	.....	.....	.....	1.18	3.26	1.42	1.24	1.10	1.93
29	.....	.....	.....	.....	.....	.....	2.38	3.25	1.35	1.24	1.09	2.00
30	.....	.....	.....	.....	.....	.....	2.33	2.99	1.30	1.17	1.04	1.99
31	.....	.....	.....	.....	.....	.....	.....	2.88	.....	1.10	1.00	.....

THE GARDEN CITY CANAL.

Location. In section 4, township 24 south, range 34 west, in Finney county, about one-half mile below head gate.

Records available. Irrigation seasons of 1920 to 1924.

Gage. Gurley automatic graphic water-stage recorder installed on south bank of canal about 40 feet downstream from wagon bridge.

Discharge measurements. Made from footbridge at gage and by wading.

Accuracy. Stage-discharge relation affected by shifting sand in bottom of canal. Banks permanent. Daily discharge ascertained by applying hourly gage heights to rating curve. Records fair.

DISCHARGE MEASUREMENTS of the Garden City canal during 1923-'24.

Date.	Made by—	Gage height.	Discharge.
1923.		Feet.	Sec.-ft.
Nov. 24	Vern W. Stambaugh	1.85	0.44

DAILY DISCHARGE, in second-feet, of Garden City canal, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1								4	23			
2							13	16	20			
3							12	32	15			
4								16	10		17	
5								11	10		16	
6								6	17		17	
7							9	5	12		21	
8							9	4	11		19	
9							8	3	10		20	
10							8	3	14		12	
11							8	5	9		14	
12							6		7		21	
13							7		5		21	
14							7		4		13	
15							7				9	
16							6				10	
17							6			16	11	
18							5		14	9	7	
19							5		11	6	2	
20							6			28	13	
21							10			38	21	
22							10			25	23	
23							7			31	35	
24							6			34	13	
25							14			33		
26							14	40		32		
27							18	39		32		
28							12	35		39		
29							7	35		25		
30							5	31		21		
31								26				
Total							225	311	192	369	335	
Mean							8.7	18.3	12.0	26.4	16.0	
Max							18	40	23	39	35	
Acre-ft							446	616	380	731	663	

DAILY DISCHARGE, in second-feet, of Garden City canal, 1923-'24.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16						18						
17						32			40			
18						31			53			
19						31			54			
20						31			54			
21						30			54			
22						21			55			
23									56			
24									57			
25									41			
26												
27												
28												
29												
30												
31												
Total						194			464			
Mean						27.7			51.6			
Max						32			57			
Acre-ft						384			919			

FARMERS' DITCH.

Location. In section 5, township 24 south, range 34 west, in Finney county, about three-fourths of a mile below head gate.

Records available. Irrigation seasons of 1920 to 1924.

Gage. Gurley automatic graphic water-stage recorder installed on north bank of canal at downstream end of wagon bridge.

Discharge measurements. Made from wagon bridge.

Accuracy. Stage-discharge relation shifting. Daily discharge ascertained by applying hourly gage heights to rating curve. Records good.

DISCHARGE MEASUREMENTS of the Farmers' Ditch during 1924.

Date.	Made by—	Gage height.	Discharge.
1924.		Feet.	Sec.-ft.
May 17	Vern W. Stambaugh	1.045	20.7
May 24	do	1.73	63.4
May 31	do	2.63	147
June 28	Stambaugh and Johnson	1.06	25 8

DAILY DISCHARGE, in second-feet, of Farmers' Ditch, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.
1	.....	.....	.....	.....	.....	.....	33	63	37	82	47	
2	.....	.....	.....	.....	.....	.....	16	57	28	67	28	
3	.....	.....	.....	.....	.....	80	.....	36	27	57	.....	
4	.....	.....	.....	.....	.....	65	16	33	32	41	.....	
5	.....	.....	.....	.....	.....	30	26	26	23	54	.....	
6	.....	.....	.....	.....	.....	58	.....	24	25	33	66	
7	.....	.....	.....	.....	.....	57	.....	19	25	22	81	
8	.....	.....	.....	.....	.....	57	.....	.....	13	17	86	
9	.....	.....	.....	.....	.....	56	.....	.....	.....	.....	87	
10	.....	.....	.....	.....	.....	57	.....	.....	.....	.....	34	
11	.....	.....	.....	.....	.....	64	.....	.....	.....	.....	64	
12	.....	.....	.....	.....	.....	64	.....	.....	.....	.....	75	
13	.....	.....	.....	.....	.....	58	.....	.....	.....	.....	76	
14	.....	.....	.....	.....	.....	54	.....	.....	.....	103	65	
15	.....	.....	.....	.....	.....	23	.....	59	.....	34	44	
16	.....	.....	.....	.....	.....	21	.....	39	.....	79	50	
17	.....	.....	.....	.....	.....	23	.....	27	.....	116	84	
18	.....	.....	.....	.....	.....	18	.....	20	.....	.....	.....	
19	.....	.....	.....	.....	.....	16	.....	.....	.....	.....	.....	
20	.....	.....	.....	.....	.....	12	.....	.....	.....	.....	.....	
21	.....	.....	.....	.....	.....	11	.....	43	.....	62	31	
22	.....	.....	.....	.....	.....	16	.....	37	.....	96	71	
23	.....	.....	.....	.....	.....	20	.....	52	.....	110	42	
24	.....	.....	.....	.....	.....	.....	.....	52	.....	133	.....	
25	.....	.....	.....	.....	.....	.....	.....	72	.....	148	.....	
26	.....	.....	.....	.....	.....	.....	90	99	.....	141	.....	
27	.....	.....	.....	.....	.....	12	63	93	.....	156	63	
28	.....	.....	.....	.....	.....	53	42	51	33	.....	94	
29	.....	.....	.....	.....	.....	56	27	60	106	61	76	
30	.....	.....	.....	.....	.....	46	18	49	104	83	42	
31	.....	.....	.....	.....	.....	36	.....	47	.....	72	65	
Total	.....	.....	.....	.....	.....	1,063	331	1,058	453	1,767	1,371	
Mean	.....	.....	.....	.....	.....	40.9	36.8	48.1	41.2	80.3	62.3	
Max	.....	.....	.....	.....	.....	80	90	99	106	156	94	
Acre-ft	.....	.....	.....	.....	.....	2,100	655	2,100	897	3,500	2,710	

DAILY DISCHARGE, in second-feet, of Farmers' Ditch, 1923-'24.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.
1	30	.....	.....	.....	.....	.....	.....	.....	118	40	.....	
2	39	.....	.....	.....	.....	.....	.....	.....	75	63	.....	
3	51	.....	.....	.....	.....	.....	.....	.....	85	53	.....	
4	30	.....	.....	.....	.....	.....	.....	.....	122	17	.....	
5	25	.....	.....	.....	.....	.....	.....	.....	124	9	.....	
6	.....	.....	.....	.....	.....	.....	.....	28	123	.....	.....	
7	.....	.....	.....	.....	.....	.....	.....	.....	80	.....	.....	
8	.....	.....	.....	.....	.....	.....	.....	.....	84	.....	.....	
9	.....	.....	.....	.....	.....	.....	.....	.....	67	17	.....	
10	.....	.....	.....	.....	.....	.....	.....	.....	59	.....	.....	
11	.....	.....	.....	.....	.....	.....	.....	.....	55	12	.....	
12	.....	.....	.....	.....	.....	.....	.....	.....	93	17	.....	
13	.....	.....	.....	.....	.....	.....	.....	.....	147	.....	.....	
14	.....	.....	.....	.....	.....	.....	.....	.....	54	.....	.....	
15	.....	.....	.....	.....	.....	.....	.....	5	34	.....	.....	
16	.....	.....	.....	.....	.....	.....	.....	22	57	.....	.....	
17	.....	.....	.....	.....	.....	.....	.....	19	122	.....	.....	
18	.....	.....	.....	.....	.....	.....	.....	14	141	.....	.....	
19	.....	.....	.....	.....	.....	.....	.....	12	159	.....	.....	
20	.....	.....	.....	.....	.....	61	.....	13	151	.....	.....	
21	.....	.....	.....	.....	.....	54	.....	30	156	.....	.....	
22	.....	.....	.....	.....	.....	54	.....	28	172	.....	.....	
23	.....	.....	.....	.....	.....	.....	.....	21	156	.....	.....	
24	.....	.....	.....	.....	.....	.....	.....	32	173	.....	.....	
25	.....	.....	.....	.....	.....	.....	.....	69	115	.....	.....	
26	.....	.....	.....	.....	.....	.....	.....	30	61	.....	.....	
27	.....	.....	.....	.....	.....	.....	.....	23	47	.....	.....	
28	.....	.....	.....	.....	.....	.....	.....	27	28	.....	.....	
29	.....	.....	.....	.....	.....	.....	.....	39	19	.....	.....	
30	.....	.....	.....	.....	.....	.....	.....	113	14	.....	.....	
31	.....	.....	.....	.....	.....	.....	.....	137	.....	.....	.....	
Total	175	.....	.....	.....	.....	169	.....	662	2,890	228	.....	
Mean	35	.....	.....	.....	.....	56.3	.....	36.8	96.3	28.5	.....	
Max	51	.....	.....	.....	.....	61	.....	137	177	63	.....	
Acre-ft	347	.....	.....	.....	.....	335	.....	1,310	5,720	451	.....	

GREAT EASTERN CANAL.

Location. In section 15, township 25 south, range 37 west, south of Hartland, in Kearny county, and about one-half mile downstream from head gate.

Records available. Irrigation seasons of 1920 to 1924.

Gage. Gurley automatic water-stage recorder, installed on south bank of canal about 150 feet upstream from highway bridge across canal.

Discharge measurements. Made from highway bridge.

Accuracy. Stage-discharge relation affected somewhat by sand deposits in bed of canal. Daily discharge ascertained by applying hourly gage heights to rating curves. Records fair.

Reservoir storage. In addition to the water diverted during the irrigation season, March to November, inclusive, about 20,000 acre-feet are, as a rule, diverted through this canal each winter for storage in Lake McKinney. Due to the large amount of water in the river in 1923 the reservoir was filled earlier than usual, and it took no water during the winter of 1923-1924.

DISCHARGE MEASUREMENTS of the Great Eastern canal during 1923-'24.

Date.	Made by—	Gage height.	Discharge.
		Feet.	Sec.-ft.
1922.			
Nov. 20	Geo. S. Knapp	1.37	51.0
1923.			
May 23	Geo. S. Knapp	3.86	430
July 14	Vern W. Stambaugh	3.22	375
Sept. 29	do	1.58	49.1
Nov. 10	do	1.4	28.6
1924.			
May 17	Vern W. Stambaugh	2.1	111
May 24	do	3.42	398
June 14	do	2.18	121

DAILY DISCHARGE, in second-feet, of Great Eastern canal, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	.....	47	.....	.....	.....	.....	.....	50	.....	164	.....
2	.....	.....	44	.....	.....	.....	.....	.....	51	.....	174	.....
3	.....	.....	53	.....	.....	.....	.....	.....	112	.....	207	.....
4	.....	.....	59	.....	.....	12	.....	.....	100	.....	374	.....
5	.....	.....	61	.....	.....	81	.....	.....	104	.....	530	.....
6	.....	.....	60	.....	.....	87	.....	.....	100	.....	289	.....
7	.....	.....	61	.....	.....	57	.....	.....	.....	.....	443	.....
8	.....	.....	47	.....	.....	.....	.....	.....	.....	.....	448	.....
9	.....	.....	23	.....	.....	.....	.....	.....	451	.....	297	.....
10	.....	.....	44	.....	.....	50	.....	.....	582	.....	231	.....
11	.....	.....	46	.....	.....	50	.....	.....	482	.....	195	.....
12	.....	.....	.....	.....	.....	50	.....	.....	395	.....	153	.....
13	.....	.....	.....	.....	.....	49	.....	.....	294	299	107	.....
14	.....	.....	.....	.....	.....	50	.....	.....	369	372	.....	.....
15	.....	.....	.....	.....	.....	38	.....	.....	277	413	.....	.....
16	.....	.....	.....	.....	.....	31	.....	.....	322	304	.....	.....
17	.....	.....	.....	.....	.....	40	.....	.....	256	112	101	.....
18	.....	55	.....	.....	.....	.....	.....	.....	183	.....	164	.....
19	.....	59	.....	.....	.....	.....	.....	.....	.....	.....	92	.....
29	.....	48	.....	.....	.....	.....	.....	.....	.....	181	65	.....
21	.....	22	.....	.....	.....	.....	.....	.....	.....	148	67	.....
22	.....	.....	.....	.....	.....	.....	.....	.....	.....	251	61	.....
23	.....	.....	.....	.....	.....	.....	.....	362	.....	334	49	.....
24	.....	.....	.....	.....	.....	.....	.....	372	.....	207	.....	.....
25	.....	.....	.....	.....	.....	.....	.....	131	.....	.....	.....	.....
26	.....	.....	.....	.....	.....	.....	.....	201	.....	.....	16	.....
27	.....	.....	.....	.....	.....	.....	.....	42	.....	.....	37	.....
28	.....	51	.....	.....	.....	.....	.....	32	.....	319	51	.....
29	.....	54	.....	.....	.....	.....	.....	30	.....	253	38	.....
30	.....	53	.....	.....	.....	.....	.....	34	.....	235	19	.....
31	.....	.....	.....	.....	.....	.....	.....	60	.....	177	.....	.....
Total	.....	342	545	.....	.....	595	.....	1,264	4,128	3,605	4,372	.....
Mean	.....	48.9	49.5	.....	.....	49.6	.....	140	258	258	175	.....
Maximum	.....	59	61	.....	.....	87	.....	372	582	413	530	.....
Acre-feet	.....	677	1,080	.....	.....	1,180	.....	2,500	8,170	7,140	8,660	.....

DAILY DISCHARGE, in second-feet, of Great Eastern canal, 1923-'24.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	211	49	.....	.....	.....	.....	.....	.....	265	.....	.....	.....
2	146	51	.....	.....	.....	.....	.....	.....	66	.....	.....	.....
3	4(	45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	2[illegible]	40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	36	37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	4(	34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	.....	26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	.....	21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	.....	21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	.....	27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	.....	31	.....	.....	.....	.....	.....	.....	92	.....	.....	.....
12	.....	27	.....	.....	.....	.....	.....	.....	337	.....	.....	.....
13	.....	26	.....	.....	.....	.....	.....	.....	219	19	.....	.....
14	.....	30	.....	.....	.....	.....	.....	.....	127	.....	.....	.....
15	.....	29	.....	.....	.....	.....	.....	.....	34	.....	.....	.....
16	44	28	.....	.....	.....	.....	.....	26	20	.....	.....	.....
17	39	27	.....	.....	.....	.....	.....	109	222	.....	.....	.....
18	75	26	.....	.....	.....	.....	.....	97	372	.....	.....	.....
19	85	26	.....	.....	.....	.....	.....	94	359	.....	.....	.....
20	62	26	.....	.....	.....	.....	.....	109	412	.....	.....	.....
21	54	27	.....	.....	.....	.....	.....	140	448	.....	.....	.....
22	44	39	.....	.....	.....	.....	.....	154	376	.....	.....	.....
23	40	49	.....	.....	.....	.....	.....	258	412	.....	.....	.....
24	50	45	.....	.....	.....	.....	.....	376	434	.....	.....	.....
25	67	41	.....	.....	.....	.....	.....	313	270	.....	.....	.....
26	63	36	.....	.....	.....	.....	.....	224	132	.....	.....	.....
27	113	33	.....	.....	.....	.....	.....	176	48	.....	.....	.....
28	86	64	.....	.....	.....	.....	.....	178	.....	.....	.....	.....
29	67	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
30	64	109	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
31	51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	1,510	1,170	.....	.....	.....	.....	.....	2,250	4,650	19	.....	.....
Mean	68.6	39	.....	.....	.....	.....	.....	173	245	19	.....	.....
Maximum	211	109	.....	.....	.....	.....	.....	376	448	19	.....	.....
Acre-feet	2,990	2,320	.....	.....	.....	.....	.....	4,460	9,210	38	.....	.....

SOUTH SIDE DITCH.

Location. In section 15, township 25 south, range 37 west, about half a mile south of Hartland, in Kearny county, and approximately one-half mile downstream from head gate.

Records available. Irrigation seasons of 1920 to 1924.

Gage. Gurley automatic water-stage recorder on south bank 100 feet upstream from highway bridge across canal.

Discharge measurements. Made from highway bridge and from flume 200 yards below gage.

Accuracy. Stage-discharge relation affected by shifting sand. New waste gate installed 100 yards below gage caused scouring of canal bottom. Banks fairly permanent. Daily discharge ascertained by applying hourly gage heights to rating curve. Records fair.

DISCHARGE MEASUREMENTS of the South Side canal, 1923-'24.

Date.	Made by—	Gage height.	Discharge.
1923.		Feet.	Sec.-ft.
May 23	Geo. S. Knapp	2.55	173
July 14	Vern W. Stambaugh	0.79	9.4
July 21	do	1.70	77.6
Sept. 22	do	1.65	20.1
1924.			
June 14	Vern W. Stambaugh	2.53	152
July 5	E. G. Johnson	.92	22.4
July 12	do	.80	23.0

DAILY DISCHARGE, in second-feet, of South Side canal, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	.....	.....	.....	.....	.....	.....	12	.....	89	.....	28
2	.....	.....	.....	.....	.....	.....	.....	24	.....	121	.....	20
3	.....	.....	.....	.....	.....	.....	.....	.....	.....	106	.....	17
4	.....	.....	.....	.....	.....	.....	.....	.....	.....	101	103	13
5	.....	.....	.....	.....	.....	.....	.....	.....	.....	79	81	14
6	.....	.....	.....	.....	.....	.....	.....	.....	.....	120	97	13
7	.....	.....	.....	.....	.....	.....	.....	.....	47	122	16	7
8	.....	.....	.....	.....	.....	.....	.....	.....	60	124	.....	.....
9	.....	.....	.....	.....	.....	.....	.....	.....	26	81	.....	.....
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	65	.....	.....
11	.....	.....	.....	.....	.....	.....	.....	.....	.....	79	.....	.....
12	.....	.....	.....	.....	.....	.....	.....	.....	.....	93	.....	.....
13	.....	.....	.....	.....	.....	.....	.....	.....	.....	159	.....	.....
14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	78	49	.....
16	.....	.....	.....	.....	.....	.....	.....	.....	.....	135	104	.....
17	.....	.....	.....	.....	.....	.....	.....	.....	.....	107	202	.....
18	.....	.....	.....	.....	.....	.....	.....	.....	21	73	149	37
19	.....	.....	.....	.....	.....	.....	.....	.....	52	92	90	33
20	.....	.....	.....	.....	.....	.....	.....	.....	37	78	73	50
21	.....	.....	.....	.....	.....	.....	.....	.....	53	73	78	30
22	.....	42	.....	.....	.....	.....	.....	.....	59	109	80	18
23	.....	43	.....	.....	.....	.....	.....	16	55	.....	72	9
24	.....	44	.....	.....	.....	.....	.....	144	.....	.....	67	5
25	.....	44	.....	.....	.....	.....	.....	98	.....	.....	83	.....
26	.....	46	.....	.....	.....	.....	.....	97	.....	.....	92	.....
27	.....	14	.....	.....	.....	.....	113	65	.....	.....	79	.....
28	.....	.....	.....	.....	.....	.....	21	.....	.....	135	65	.....
29	.....	.....	.....	.....	.....	.....	.....	.....	85	151	52	.....
30	.....	.....	.....	.....	.....	.....	.....	.....	86	158	60	.....
31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	37	.....
Total	.....	233	.....	.....	.....	.....	134	456	581	2,528	1,729	294
Mean	.....	38.8	.....	.....	.....	.....	67.0	65.1	52.8	105	82.3	21.0
Maximum	.....	46	.....	.....	.....	.....	113	144	86	159	202	50
Acre-feet	.....	461	.....	.....	.....	.....	265	903	1,150	5,010	3,420	582

DISCHARGE MEASUREMENTS of Arkansas river at Larned, 1923-'24.

DATE.	Made by—	Gage height.	Discharge.
1923.		Feet.	Sec.-ft.
June 4	Geo. S. Knapp	4.40	484
June 25	Knapp and Stambaugh	5.71	1,900
June 26	do	6.05	2,520
July 11	Vern W. Stambaugh	3.43	103
July 18	do	3.64	235
July 19	do	4.60	887
Aug. 20	do	7.00	5,130
Aug. 20	do	8.39	9,740
Oct. 1	do	5.15	1,270
Nov. 19	do	5.05	968
Nov. 30	do	4.77	662
1924.			
Mar. 4	Vern W. Stambaugh	4.92	695
Mar. 31	do	5.72	1,940
May 9	do	4.69	480
June 21	Stambaugh and Johnson	3.68	13.7
July 21	do	3.57	6.5

DAILY GAGE HEIGHT, in feet, of Arkansas river at Larned, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.
1	1.17	.95	1.05	.....	.96	3.00	2.90	3.05	5.11	4.45	5.02	6.71
2	1.16	.94	1.06	.....	.96	2.97	2.85	3.06	5.08	4.32	4.81	6.23
3	1.15	.92	1.06	.....	.96	3.02	2.80	3.21	4.73	4.19	4.70	5.99
4	1.15	.91	1.06	.....	.96	.....	2.83	3.25	4.53	4.06	4.61	5.68
5	1.14	.95	.....	.....	.96	.....	2.85	3.38	4.79	3.95	4.51	5.47
6	1.13	.94	.....	.....	.97	.....	2.83	3.38	4.55	3.82	5.33	5.32
7	1.12	.94	.....	.....	.98	.....	2.78	3.37	4.34	3.70	5.49	5.18
8	1.12	.94	.....	.....	.99	.....	2.74	3.31	4.39	3.58	5.16	5.27
9	1.11	.90	.....	.....	1.02	.....	2.74	3.22	4.88	3.47	4.99	5.18
10	1.10	.86	.....	.....	1.03	.....	2.68	3.19	5.01	3.35	5.16	5.05
11	1.09	.84	.....	.....	1.02	2.96	2.66	3.08	5.00	3.25	5.07	5.00
12	1.09	.82	.....	.....	1.02	3.00	2.65	2.98	6.55	3.32	5.90	4.89
13	1.08	.82	.....	.....	1.01	2.97	2.67	3.00	6.02	3.37	5.38	4.93
14	1.07	.79	.....	.....	1.01	2.93	2.65	3.11	5.47	3.38	5.25	4.94
15	1.06	.78	.....	.....	1.00	2.85	2.62	3.27	5.05	3.42	5.21	4.87
16	1.06	.79	.....	.....	1.00	2.85	2.62	3.37	4.78	3.53	5.83	4.93
17	1.05	.82	.....	.....	.....	2.86	2.62	3.47	4.56	3.55	6.89	4.91
18	1.04	.87	.....	.....	.....	2.76	2.64	3.52	4.47	3.66	5.40	5.00
19	1.03	.91	.....	.96	.....	2.65	2.66	3.54	5.59	4.54	5.81	5.17
20	1.03	.94	.....	.96	.....	2.74	2.77	3.49	7.31	4.29	6.89	5.63
21	1.02	.96	.....	.96	.....	2.84	2.81	3.48	6.54	4.86	7.21	5.78
22	1.01	.99	.....	.96	2.88	2.78	2.74	3.58	6.09	6.29	6.55	6.46
23	1.00	1.01	.....	.96	2.88	2.98	2.70	3.19	6.47	5.82	6.27	6.13
24	1.00	1.03	.....	.96	2.93	3.00	2.64	3.18	6.42	5.33	6.31	5.87
25	.99	1.04	.....	.96	2.96	3.02	2.66	5.59	5.95	5.13	8.98	5.67
26	.99	1.05	.....	.96	3.03	3.02	2.94	5.90	5.95	5.13	7.88	5.56
27	.98	1.05	.....	.96	3.06	3.02	2.99	5.50	5.38	4.78	7.84	5.48
28	.98	1.05	.....	.96	3.03	3.04	3.04	5.11	4.96	4.61	7.27	5.40
29	.97	1.04	.....	.96	.....	2.99	3.10	4.71	4.72	4.50	6.73	5.30
30	.98	1.05	.....	.96	.....	2.93	3.09	4.62	4.58	5.12	6.39	5.22
31	.97	.....	.....	.96	.....	2.90	.....	4.65	.....	5.46	6.12	.....

DAILY GAGE HEIGHT, in feet, of Arkansas river at Larned for 1923-'24.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	5.15	5.74	4.70	.....	5 98	....	.....	5.63	4.27	3.68	2.52	.....
2	5.10	5.79	4.68	.....	5.76	....	5 87	5.26	4.21	3.74	2.46	.....
3	5.03	5.78	4 73	.....	5 88	5 05	5.73	5.13	4.14	3.69	2.40	.....
4	4.98	5.73	4 75	.....	.....	4.92	5 62	5.12	4.11	3.63	2 34	.....
5	4.94	5.62	4 72	.....	.....	.....	5.51	5 07	4.06	3.56	2.28	.....
6	4.99	5.54	4 71	.....	.....	.....	5.42	4.95	....	3.52	2.43	.....
7	5.03	5.48	4.73	.....	.....	4.78	5.33	4.85	3.93	3.50	2.31	.....
8	5.84	5.46	4.73	.....	.....	.....	5 27	4.75	3 93	3.45	2.26	.....
9	6.25	5.35	4.71	.....	.....	.....	5.21	4.68	3.93	3.41	2.21	.....
10	6.10	5.26	4.69	.....	.....	.....	5.21	4.60	3.91	3.23	2.19	.....
11	6.68	5.24	4.69	.....	.....	.....	5.17	4.53	3.89	3.09	2.22	.....
12	7.19	5.25	4.71	.....	5.75	.....	5.24	4.48	3.87	2.98	2.17	.....
13	7.17	5.24	4.62	.....	.....	.....	5.36	4.44	3.86	3.05	2.13	.....
14	7.01	5.25	4.49	.....	.....	.....	5.42	4.38	3.85	3.50	2.35	.....
15	6.60	5.19	4.63	.....	.....	.....	5.40	4 34	3.82	3.57	4.00	.....
16	6.27	5.16	4.56	.....	.....	.....	5 43	4.29	3.80	3.53	3.72	.....
17	6.26	5.13	4.53	.....	.....	.....	5.44	4.23	3.77	3.51	3.61	.....
18	6.25	5.09	4.67	.....	5.30	.....	5.43	4.20	3.80	3.70	3.59	.....
19	6 10	5.05	4.60	.....	.....	.....	5.31	4.17	3.78	3.76	3.39	.....
20	5.95	5.02	4.59	.....	.....	4.60	5.40	4.12	3.72	3.77	3.17	.....
21	5.87	4.98	4 85	5.25	.....	.....	5.48	4.08	3.69	3.64	3.07	.....
22	5.80	4.95	4.87	5.26	.....	.....	5.45	4.04	3.66	3.54	3.00	.....
23	5.75	4.94	4 85	5.30	5.20	.....	5.37	4.00	3.61	3.40	2.89	.....
24	5.69	4.92	5.05	5.39	.....	.....	5.24	3.98	3.77	3.14	2.79	.....
25	5.64	4.88	5.11	.....	.....	.....	5.07	3.97	3.89	2.97	2.68	.....
26	5.61	4.87	5.05	.....	.....	.....	4.99	3.99	3.94	2.86	2.57	.....
27	5.83	4.87	5.09	5.51	.....	6.00	4.90	4.16	4.04	2.77	2.46	.....
28	5.81	4.84	5.11	.....	.....	.....	4.92	4.12	3.92	2.70	2.36	.....
29	6.13	4.81	5.08	5.48	5.27	.....	5.89	5.15	3.76	2.77	2.25	.....
30	5.97	4.77	5.09	5.47	.....	.....	6.06	4.14	3.72	2.65	2.14	.....
31	5.82	.....	.....	5.62	.....	5.74	.....	4.20	.....	2.58	2.04	.....

DAILY DISCHARGE, in second-feet, of Arkansas river at Larned, 1922-'23.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	0	0	0	0	0	18	10	25	1,080	527	1,190	4,520
2	0	0	0	0	0	16	6	26	1,080	464	970	3,270
3	0	0	0	0	0	21	2	52	746	384	830	2,560
4	0	0	0	0	0	20	4.4	59	595	334	746	2,060
5	0	0	0	0	0	20	6	84	786	277	668	1,730
6	0	0	0	0	0	19	4.4	84	595	223	527	1,510
7	0	0	0	0	0	18	1.5	82	364	184	1,730	1,310
8	0	0	0	0	0	18	.3	70	494	145	1,310	1,440
9	0	0	0	0	0	17	.3	54	874	114	1,080	1,310
10	0	0	0	0	0	16	0	48	970	84	1,250	1,140
11	0	0	0	0	0	15	0	29	970	66	1,140	1,080
12	0	0	0	0	0	18	0	16	3,950	86	2,450	970
13	0	0	0	0	0	16	0	18	2,450	106	1,510	1,020
14	0	0	0	0	0	12	0	34	1,510	117	1,310	1,020
15	0	0	0	0	0	6	0	63	1,020	134	1,250	970
16	0	0	0	0	0	6	0	82	786	174	2,160	1,020
17	0	0	0	0	0	6.8	0	106	595	190	4,820	1,020
18	0	0	0	0	0	.9	0	120	527	244	1,440	1,080
19	0	0	0	0	0	0	0	125	1,730	830	2,060	1,310
20	0	0	0	0	0	.3	1.2	111	6,060	630	4,820	1,980
21	0	0	0	0	0	5.2	2.8	109	3,670	1,140	5,750	2,250
22	0	0	0	0	8.4	1.5	.3	136	2,660	3,950	3,950	3,950
23	0	0	0	0	8.4	16	0	48	3,540	2,660	3,140	3,020
24	0	0	0	0	12	18	0	46	3,400	1,730	3,140	2,450
25	0	0	0	0	15	21	0	1,730	2,350	1,440	12,200	2,060
26	0	0	0	0	22	21	13	2,250	2,350	1,440	8,010	1,890
27	0	0	0	0	26	21	17	1,580	1,440	970	7,670	1,730
28	0	0	0	0	22	24	24	1,080	922	830	6,060	1,580
29	0	0	0	0	.....	17	32	706	706	706	4,520	1,440
30	0	0	0	0	.....	12	31	630	630	1,380	3,670	1,360
31	0	.....	0	0	.....	10	.....	668	.....	1,810	3,020	.....
Total	0	0	0	0	113.8	430.7	156.2	10,271	48,850	23,369	94,391	54,050
Mean	0	0	0	0	4.06	13.9	5.21	331	1,630	754	3,040	1,800
Max	0	0	0	0	26	24	32	2,250	6,060	3,950	12,200	4,520
Min	0	0	0	0	0	0	0	16	364	66	527	970
Acre-ft	0	0	0	0	225	855	310	20.400	97.000	46,400	187.000	107,000

CHAPTER III.

THE IRRIGATION PROBLEM IN KANSAS.

Address delivered at annual meeting, American Society of Agricultural Engineers, Lincoln, Neb., June 18, 1924, by GEO. S. KNAPP.

The irrigation problem in Kansas differs strikingly from that in many of the other states where irrigation is a recognized institution. This is largely because of differences in climate and water supply.

Throughout the Western states, where very little can be raised without irrigation, there are millions of acres of good fertile land. This land for the most part is valueless without water, but the supply of water is inadequate to ever irrigate more than a small portion of it. Because of this the value of a tract of land depends largely on the water available, and the water right for an acre of land is usually worth considerably more than the land itself. With this condition, the production per unit of water is frequently more important than the yield per acre.

Sound public policy in the Western states requires that the largest possible production be secured with the water used, and we find that the activities of these states have wisely been directed toward securing greater economy in the use of water in order that more acres of land may be brought under cultivation. Laws enacted by the Western states have been of a regulatory nature, designed to control and supervise the use of water. Agricultural colleges and experiment stations have carried on multitudinous experiments, the purpose of which is to teach greater economy in the use of water and thus secure a higher "duty of water"—a term almost never heard in connection with Kansas irrigation.

In contrast to this, Kansas is to-day exercising little or no regulatory control over the use of water. Laws on the statute books for that purpose are for the most part inoperative, because they do not deal with present-day conditions, and what influence the state is having with regard to irrigation is directed toward encouraging the greater use of water.

Differences in climate and water supply are largely responsible for these conditions. There is no part of the state of Kansas where crops cannot be grown without irrigation. Rainfall varies from about sixteen inches at the western end of the state to more than forty inches in the southeast corner. In the western counties such crops as kafir, milo, wheat and other small grains are grown without irrigation, but do not yield as well without irrigation as where irrigated, and in dry years may be almost a failure. In the central and eastern portions all crops common to the humid states are grown. Frequently the yield is as great as in the humid states. On other years a drought in July and August may seriously damage a crop which had promise of a satisfactory yield, although the rainfall may be but a few inches below normal. In the western portion irrigation will result in increased yields every year, and in the eastern part, where water is available, the application of but a few inches of water at a critical period will often save a crop from serious injury by drought.

Very little surface water is available for irrigation in Kansas. In the Garden City district there are a number of canals taking water from the Arkansas river, but they are using the entire available supply, and new development

must depend almost wholly on ground water. There is hardly a place in western Kansas where a sufficient supply of ground water cannot be found, but the depth to water on the uplands is too great for economical irrigation. For that reason new development is confined to the valley lands of the state, of which there are about five million acres. In the valleys this water is found in beds of waterlaid sand and gravel subsequently covered with alluvial deposits of soil. The depth to water in such valleys varies from eight to twenty feet. This water is recovered by pumping, and the pumping heads range from fifteen to forty feet.

As far as is known, this water supply is adequate for the irrigation of all land under which it is found, and there appears to be no reason to regulate or restrict its use. In some localities there are pumping plants on almost every farm. These plants have capacities ranging in size from two to as much as eight cubic feet per second. Many of them have been in operation more than ten years. During the irrigation season when many of the plants have been in operation almost continuously the water table has been lowered from two to four feet by pumping, but in no year has the water supply been exhausted to the point where the water plane has not recovered its normal elevation long before the next irrigation season. There has in this period been no decrease in the available supply.

In that type of pumping plant in most common use, a horizontal centrifugal pump is set in a pit just above the water plane. The pump is driven either by an electric motor or an internal-combustion engine. In a few instances farm tractors are used. The well system consists of a number of wells, usually placed in a straight line and spaced 40 feet apart. In the construction of the wells, open pits about five feet in diameter are dug down to the water and walled up with cement blocks or concrete. A perforated well casing 16 inches in diameter is then sunk through the entire water-bearing stratum by the use of a sand bucket. Where the water-bearing material is 25 or 30 feet thick and is composed of fairly coarse sand and gravel, about 250 gallons per minute can be expected from each well.

The cost of a pumping plant will of course vary with local conditions of water supply, but as a rule a plant large enough to irrigate 160 acres of land, *i. e.*, having a capacity of 3 or 4 cubic feet per second, can be put in for $2,000. This would be a construction charge of $12.50 per acre—a cost which is remarkably low when compared with the cost of irrigation enterprises in the West, very few of which can be built for less than $50 to $100 an acre. The cost of pumping will range from $1.50 to $2.25 an acre-foot with electric energy at 4 cents per kilowatt hour. Where more than an acre-foot per acre is used the cost of pumping would probably exceed the annual maintenance and operating charges on a gravity project, but if the difference between the construction cost of the pumping plant and the gravity project were invested at six per cent, the income would more than cover the cost of pumping and the owner of the pumping plant would still obtain cheaper water than the farmer under the gravity project.

The pumping-plant irrigation project is entirely an individual enterprise. It is optional with the farmer whether or not he will install a pumping plant on his farm, and if he does install one he has no one to consult but himself regarding the use of water. The questions he is interested in are, first, Will the increased yields obtained through its use justify him in making the neces-

sary investment? and second, If he does install it, what is the proper amount of water to apply?

It is easily seen that where the supply of water is, for practical purposes, unlimited, and where the farmer can obtain water whenever he wants it, but does not need to pay for more than he actually uses, the question resolves itself into, not necessarily what amount of water will produce the maximum yield per unit of water, but what amount of water will make the largest net return when all items affecting the cost of production are taken into consideration.

For a number of years experiments in the use of water have been carried on at the Garden City Experiment Station, a branch of the Kansas State Agricultural College. The results of some of this work are reported in a recent publication.[1] In order to make a comparison of the relative profit or loss between dry-land and irrigation farming, and to determine the economy of the use of various amounts of water, four of the crops used in these experiments—milo, kafir, wheat and barley—are considered here. The yields and amounts of water are shown in Table 1.

LAND AND LABOR COSTS.

To arrive at the cost of growing the crop, the investment in unirrigated land is assumed to be $60 an acre, and an annual charge of 8 per cent on that amount, or $4.80 an acre, is made to cover interest and taxes.

A basic charge is made of $2 per day for a man and $1 a day for a horse. This may be above or below the prevailing price in any particular locality, but it undoubtedly will afford a profitable market to the farmer for his labor. The time required for men and teams to cover a given acreage in each of the several farm operations obviously varies with soils and other conditions. The average shown in Table 2 has been determined by the United States Department of Agriculture[2] from the actual experience of a large number of men over a wide range of conditions for many years. Table 2 also shows the cost per acre for each operation, based upon what is considered an average day's work. Table 3 shows the average number of field operations involved in the production of the crops reported on in this paper. These operations charged at the price per acre shown in Table 2 comprise the tillage and harvesting charges made in Table 5.

These charges are fixed charges for each acre, and do not vary greatly with the yield per acre, except possibly the charges for twine and shocking, which are so small that they cannot materially affect the relative cost of producing the various crops.

Seed is charged for at the same price per bushel that is given the various crops in Table 4. Milo and kafir were planted at the rate of six pounds per acre, and wheat and barley sown at the rate of three pecks per acre.

Binder wear and repair is calculated at 15 cents per acre, but no allowance is made for wear or depreciation on the other farm machinery.

A charge of 10 cents per bushel is made for threshing all crops. This is believed sufficient to cover the cost of taking the grain from the shock and putting the threshed grain in the bin.

1. Knapp, Geo. S. Relation of Crop Yields to Quantity of Irrigation Water in Southwestern Kansas. Bulletin 228, Kansas Agricultural Experiment Station; 1922.

2. Chilcott, E. C., Cole, J. S., and Burr, W. W. Spring Wheat in the Great Plains Area. Bulletin No. 214, U. S. Department of Agriculture; May 1915.

TABLE 1. Effect of quantity of irrigation water on crop yields at Garden City.

Year.	Unirrigated.		"D" series.			"C" series.			"B" series.			"A" series.		
	Grain.	Stover.	Water.	Grain.	Stover.	Water.	Grain.	Stover.	Water.	Grain.	Stover.	Water.	Grain.	Stover.
MILO.														
1915	37 9	3,367	11 5	33 7	6,200	11 5	47.8	7,400	14 9	53.6	8,800	21.1	57.6	9,800
1916	1 5	1,873	5 2	7 5	4,200	11.3	16.3	5,800	14.3	41.5	6,200	21.3	58.6	8,200
1917	0 0	1,207	8 2	0 0	2,200	13 8	28 8	2,600	21.6	41.8	2,800	29.7	43.7	3,800
1918	2 1	883	12 7	20 1	4,000	18 6	57.8	8,200	21.5	55.4	9,000	26.5	59.1	7,200
Average	10 4	1,832	9 4	15 3	4,150	13 8	37.7	6,000	18.1	48.1	6,700	24.7	54.7	7,250
KAFIR.														
1915	30 9	5,370	11 5	42 5	7,200	11 5	40 1	9,000	14 9	42.7	8,200	21.1	40.5	8,800
1916	1 1	2,838	5 2	8 5	4,800	11 3	21.1	7,800	14.3	42.4	9,000	21.3	46.2	10,200
1917	0 0	2,300	8 2	0 0	2,200	13 8	23 1	5,000	21.6	22.9	4,800	29.7	29.1	4,600
1918	2 0	1,142	12 7	2 1	2 000	12 7	3.0	2,400	19 5	9 8	2,600	23.1	18.2	3,800
Average	8 5	2,830	9 4	13 3	4,050	12 3	21 8	6,050	17 6	29 5	6,150	23.8	33.5	6,850
WHEAT.														
1915	10 7	2,145	4 1	25.3	3,000	9 1	32.1	3,270	11.0	26.0	2,740	14.3	28.8	2,950
1916	0 0	0	8 9	15 6	1,300	13 5	20.3	1,705	20.6	26.9	2,585	34.5	29.1	2,660
1917	0 0	0	8 8	0.0	0	8.8	.1	117	15.8	1.4	715	19.3	1.2	875
1918	0 0	0	8 0	3 3	1,100	8 0	11.0	1,170	16.6	12.2	1,940	22.2	16.8	1,790
1919	20 1	2,745	11 8	23 0	2,560	11.8	33.0	3,120	14.5	29.0	2,860	18.5	34.5	3,780
Average	6 1	978	8 3	13 4	1,592	10.2	19.3	1,876	15.7	19.1	2,168	21.8	22.1	2,411
BARLEY.														
1915	24 3	1,610	4.1	43.3	1,520	8.1	39.6	2,400	10.1	53.2	2,960	14.7	63.1	3,490
1916	1 7	546	6 1	14.5	1,400	12.8	18.1	1,730	17.4	27.3	2,190	33.9	29.6	2,715
1917	0.0	0	7 2	.4	230	7.2	.6	120	9.2	3.0	455	10.2	2.7	470
1918	0 0	0	8 3	3.4	740	17.3	6.2	700	17.3	8.3	750	27.1	10.6	840
1919	14 6	1,463	6 9	20.3	1,325	6.9	22.0	1,395	14.6	28.9	1,363	22.3	26.3	1,440
Average	8 1	724	6 5	16 4	1,043	10.5	17.3	1,269	13.7	24.1	1,544	21.6	26.5	1,791

IRRIGATION COSTS.

In the case of the irrigated land there is added to the dry-land investment of $60 an acre a charge of $2,500 for the irrigation pumping plant. Assuming that this plant will serve 160 acres of land, the additional investment for the irrigation plant is $15.63 per acre. Interest and taxes on this additional investment at 8 per cent makes an annual charge of $1.25 per acre. The annual depreciation is assumed to be 5 per cent. This amounts to a total of $125 per year and constitutes an annual charge of $0.78 per acre on the irrigated farm.

The charge for interest, taxes and depreciation on the pumping plant, amounting to $2.03 per acre, is considered an annual charge on each acre of land included in the irrigation project, irrespective of the amount of water applied. These items are affected but little by the amount of time the

TABLE 2. Average cost per acre of farm operations involved in production of crops.

Operation.	Force employed.		Days' work.	Item cost.	Cost per acre.
	Men.	Horses.			
Plowing	1	4	3½	.....	$1.71
Disking	1	4	8	.....	.75
Harrowing	1	4	35	.....	.17
Leveling	1	4	5	.....	1.00
Subsoiling	1	3	3½	.....	1.43
Drilling	1	4	15	.....	.40
Planting	1	2	12	.....	.33
Cultivating	1	2	6	.....	.67
Listing	1	2	5	.....	.80
Harvesting	1	4	15	$0.40	.40
Shocking	1	.....	15	.13	.13
Twine	.....	.....	.....	.25	.25
Binder wear and repair	.....	.....	.....	.15	.15
Irrigating	1	.....	.....	.....	.33

TABLE 3. Number of field operations.

Crop.	Field operations.									
	Plowing.	Harrowing.	Disking.	Subsoiling.	Listing.	Leveling.	Drilling.	Planting.	Cultivating.	Irrigating.
Milo:										
Unirrigated	⅔	¾	½	.....	⅓	.....	.....	1	2	.....
"D" series	1	1	2	.....	.....	1	.....	1	2	1
"C" series	1	1	2	.....	.....	1	.....	1	2	2
"B" series	1	1	2	.....	.....	1	.....	1	2	3
"A" series	1	1	2	.....	.....	1	.....	1	2	4
Kafir:										
Unirrigated	⅔	¾	½	.....	⅓	.....	.....	1	2	.....
"D" series	1	1	2	.....	.....	1	.....	1	2	1
"C" series	1	1	2	.....	.....	1	.....	1	2	2
"B" series	1	1	2	.....	.....	1	.....	1	2	3
"A" series	1	1	2	.....	.....	1	.....	1	2	4
Wheat:										
Unirrigated	¼	¾	4	1/6	¼	.....	1	.....	½	.....
"D" series	1	1	2	.....	.....	1	1	.....	.....	1
"C" series	1	1	2	.....	.....	1	1	.....	.....	2
"B" series	1	1	2	.....	.....	1	1	.....	.....	3
"A" series	1	1	2	.....	.....	1	1	.....	.....	
Barley:										
Unirrigated	¼	¾	4	1/6	¼	.....	1	.....	½	.....
"D" series	1	1	2	.....	.....	1	1	.....	.....	1
"C" series	1	1	2	.....	.....	1	1	.....	.....	2
"B" series	1	1	2	.....	.....	1	1	.....	.....	3
"A" series	1	1	2	.....	.....	1	1	.....	.....	4

plant is operated. The liberal use of water will not increase them appreciably; stinted use of water, even though it may fail to produce a profitable crop, cannot materially reduce them, and failure to operate the plant cannot eliminate them from the expenses which the farmer must meet after he has installed his plant. Irrigation water is charged to the land at the rate of $2 per acre foot.

CROP VALUES.

Table 4 shows the price per bushel of grain and price per ton of stover which has been used in determining the value of the various crops under investigation. These figures are furnished by the Kansas State Board of

TABLE 4. Average price received by the farmer for his crop.

Year.	Wheat, bushels.	Barley, bushels.	Milo.		Kafir.	
			Bushels.	Tons.	Bushels.	Tons.
1912	$0.80	$0.71	.....	.....	.....	.....
1913	.78	.50	.....	.....	.....	.....
1914	.83	.46	.....	.....	.....	.....
1915	.89	.42	$0.44	$1.46	$0.46	$2.00
1916	1.35	.69	.98	3.19	.98	3.22
1917	2.06	1.00	1.43	4.67	1.42	5.26
1918	2.00	.98	1.50	5.60	1.55	5.85
1919	1.98	1.00	1.21	5.30	1.34	5.32
1920	1.86	.74	.73	2.73	.76	3.54
1921	.97	.30	.33	1.72	.33	2.25
Average 1912-1921	$1.35	$0.68	.....	.....	.....	.....
Average 1915-1921	1.59	.73	$0.97	$3.52	$0.98	$3.92

Agriculture and represent the average price received by the farmer for his crop as reported by more than 2,000 crop reporters for the Board, located in all parts of the state. No figures on milo and kafir are available prior to 1915. For that reason averages for the seven-year period, 1915 to 1921, inclusive, are used in the determination of crop values. An examination of the figures showing the ten-year average for wheat, oats and barley indicates that the seven-year average is probably higher than a normal price; however, it seems to be the most reliable information obtainable.

TABLE 5. Acre costs, crop values, and resulting profit or loss.

	Interest and taxes.	Tillage.	Seed.	Harvesting.	Threshing.	Interest, taxes and depreciation.	Cost of pumping.	Labor irrigating.	Total cost.	Value of crop.	Net profit.
MILO.											
Unirrigated	$4.80	$3.58	$0.10	$0.93	$1.04				$10.45	$13.31	$2.86
"D" series	4.80	6.05	.10	.93	1.53	$2.03	$1.56	$0.33	17.33	22.14	4.81
"C" series	4.80	6.05	.10	.93	3.77	2.03	2.30	.67	20.65	47.13	26.48
"B" series	4.80	6.05	.10	.93	4.81	2.03	3.01	1.00	22.73	58.44	35.71
"A" series	4.80	6.05	.10	.93	5.47	2.03	4.12	1.34	24.84	64.85	40.01
KAFIR.											
Unirrigated	$4.80	$3.58	$0.10	$0.93	$0.85				$10.26	$13.78	$3.52
"D" series	4.80	6.05	.10	.93	1.33	$2.03	$1.56	$0.33	17.13	20.97	3.84
"C" series	4.80	6.05	.10	.93	2.18	2.03	2.05	.67	18.81	33.21	14.40
"B" series	4.80	6.05	.10	.93	2.95	2.03	2.93	1.00	20.79	40.92	20.13
"A" series	4.80	6.05	.10	.93	3.35	2.03	3.97	1.34	22.57	46.26	23.69
WHEAT.											
Unirrigated	$4.80	$5.48	$1.19	$0.93	$0.61				$13.01	$9.70	—$3.31
"D" series	4.80	4.78	1.19	.93	1.34	$2.03	$1.38	$0.33	16.78	21.30	4.52
"C" series	4.80	4.78	1.19	.93	1.93	2.03	1.70	.67	18.03	30.69	12.66
"B" series	4.80	4.78	1.19	.93	1.91	2.03	2.32	1.00	18.96	30.37	11.41
"A" series	4.80	4.78	1.19	.93	2.21	2.03	3.83	1.34	21.11	35.15	14.04
BARLEY.											
Unirrigated	$4.80	$5.48	$0.55	$0.93	$0.81				$12.57	$5.91	—$6.66
"D" series	4.80	4.78	.55	.93	1.64	$2.03	$1.08	$0.33	16.14	11.97	—4.17
"C" series	4.80	4.78	.55	.93	1.73	2.03	1.75	.67	17.24	12.63	—4 61
"B" series	4.80	4 78	.55	.93	2.41	2.03	2.28	1.00	18.78	17.59	—1.91
"A" series	4.80	4.78	.55	.93	2.65	2.03	3.80	1.34	20.88	19.34	—1.51

ANALYSIS OF FACTORS ENTERING INTO THE COST OF PRODUCTION.

Table 5 shows the various items of expense involved in the production of the several crops. This table shows in detail the charges for interest and taxes on the land, tillage, seed, harvesting, threshing, interest, taxes and depreciation on the irrigation pumping plant, cost of pumping the water used, and the cost for irrigating or distributing the water in the field. In addition to this there is also shown the total cost of producing the crop, the value of the crop, and the net profit.

An examination of these data will show at once a very fundamental principle of the economics of crop production, but one which is too often disregarded when the farmer is attempting to decide on the amount of water he should give the crop; namely, that a considerable portion of the total expense of producing the crop is a fixed charge which bears no relation to the yield of that crop. It is further apparent that this fixed expense does not vary greatly with different kinds of crops. Tillage costs may vary somewhat with the needs of different crops, or with methods calculated to conserve moisture, as, for example, the unirrigated small grains, wheat and barley, where the expense was increased somewhat by double disking the stubble immediately after harvest to create a dust mulch, and in some years cultivating later in the season to kill weed growth; but even this did not materially affect the total cost. Threshing of course, varied with the yield, but that was practically the only item which was not fixed in advance in the case of the unirrigated crop. The cost of pumping the water and distributing it in the field constituted the chief variable expense of the irrigated crops, but if by increasing the water a sufficient increase in yield can be effected, the cost of water becomes an investment instead of an expense. From these data it is evident that with many crops the additional charge for a liberal application of water becomes an exceedingly good investment.

Because of the fact that the yield of dry matter per acre for each inch of irrigation usually decreases as the total amount of water used during the season increases, and perhaps partly as a matter of public policy, many irrigation publications assert that the more water that is given a crop by irrigation the less we get in return per each unit of water applied, and emphasize the folly of using large amounts of water in growing any crop. While the production of dry matter per unit of water does in fact usually decrease as larger amounts of water are applied, the farmer, particularly if he takes this interpretation too literally, can easily conclude that he can afford to apply no more than enough water to allow the crop to mature a very ordinary yield, which might be true if the cost of such water was the only item entering into the production of the crop. Considering, however, that the farmer has set aside one year's use of his land for the production of the crop, has spent considerable labor and money in soil preparation, seed and cultivation, all of which are the same regardless of the yield, and has but to increase or diminish the cost of one item—water—to materially affect the yield and the resulting profit, it is not hard to believe that the stinted use of water may often fail to produce a crop which will pay the fixed charges, while the increased use of water, even though its unit efficiency is not as great, may increase the yield sufficiently to cover all costs and leave a margin of profit.

The problem, of course, does differ depending on whether the water supply is obtained from a gravity system or from an individual pumping plant pumping from wells. In the former case the farmer usually is allotted a predetermined amount of water which he may use as he sees fit, and in the event that the water is more valuable than the land, he may find it more profitable to obtain high yield per unit of water rather than a high yield per acre of land. In the latter case he has made a heavy investment in an irrigation pumping plant upon which he must meet annual charges of interest, taxes and depreciation, regardless of the amount he uses the plant. These items constitute a considerable part of the total cost of pump irrigation. The underground supply from which the water is obtained, for all practical purposes, is adequate, if not unlimited. The chief object in this case is not to produce the greatest yield per unit of water, but to produce a yield sufficient to cover the fixed charges as well as the cost of water, and still leave a margin of profit.

Consulting the data presented, we find that the yield of dry matter per unit of water did in most instances decrease as larger amounts were applied, but we do not find that the amount of water which produced the greatest unit yield produced the greatest net profit.

Milo, for example, produced the greatest unit yield, 2.7 bushels per inch of water, with about 14 inches of water, but the application of this amount left a profit of but $26.48, while 24 inches left a profit of $40.01. Milo is one of the best irrigated crops in western Kansas, but all other crops showed greater net profits (or in the case of unprofitable crops, smaller loss) with amounts of water considerably in excess of the amounts giving the highest unit yields.

Most Kansas farmers have followed the commonly accepted theory with regard to the irrigation of their crops, and have applied only enough water to obtain very ordinary yields, often leaving them no greater profit than the man who does not irrigate. At Garden City, where a power company supplies electricity for pumping to several hundred farmers, an examination shows that less than a half dozen farmers are using power to the extent of more than one dollar per acre annually. This means that the others are using much less than one acre-foot per acre of irrigation water. Many of them obtain yields but little better than their neighbor who farms "dry," and as a result they often doubt, or at least do not appreciate, the value of irrigation. This condition must be corrected.

The problem, therefore, resolves itself into one of showing the relative importance of the various factors entering into the cost of the irrigated crop, and thus encouraging the use of larger amounts of water.

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AUG 1 2 1927

Reprint from the Twenty-fifth Biennial Report of the State Board of Agriculture.

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REPORT *of the*

STATE

IRRIGATION COMMISSIONER

TO THE

KANSAS STATE BOARD OF AGRICULTURE

For the Biennium
July 1, 1924, to June 30, 1926

PRINTED BY KANSAS STATE PRINTING PLANT
B. P. WALKER, STATE PRINTER
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1926

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LETTER OF TRANSMITTAL.

To the Kansas State Board of Agriculture:

I have the honor to transmit herewith a report of the Division of Irrigation for the biennium, July 1, 1924, to June 30, 1926.

Very respectfully, GEO. S. KNAPP,
State Irrigation Commissioner.

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REPORT OF THE COMMISSIONER.

CHAPTER I.

DEPARTMENT ACTIVITIES.

The past two years have been outstanding in the development of pump irrigation, and with the exception of some time spent on the proposed Arkansas river compact in the summer of 1925, practically the entire time of the department has been spent on that work. While this development has not added greatly to the irrigated acreage of the state, it is remarkable because of its scope.

Until a few years ago but little irrigating was done east of Garden City. Three or four years ago an occasional farmer in that section of the valley between Dodge City and Hutchinson installed an irrigation pumping plant for the purpose of getting first-hand information on the value of irrigation. The results obtained were in every instance so satisfactory that business men throughout the Arkansas valley began to realize that the adoption of irrigation in that valley would do much to insure crops against short periods of dry weather so common to a large portion of Kansas. With these results in mind, chambers of commerce throughout the Arkansas valley, knowing that the prosperity of the business man and the merchant was linked closely with that of the farmer, began to establish irrigation demonstation farms in their respective communities for the purpose of bringing to the attention of the farmer the value of irrigation. This movement has spread until, during the summer of 1926, fourteen chambers of commerce were conducting irrigation demonstrations. Numerous other pumping plants have been put in by private parties in all parts of the state, a number of which are in the eastern third where it has been commonly supposed there is no need for irrigation.

This work has brought out a number of interesting things: First, it has shown that the function of irrigation in Kansas is one of supplementary water, or crop insurance, and not one of reclamation. The two are quite different in theory and in their economical application. In the arid West, land for the most part is valueless without water, and the value of irrigated land lies in the water right. In the more humid region in which Kansas is located, the agricultural land is for the most part already in well improved farms, and land values are high. In the river valleys, and near the cities, values are so high that the successful farmer must produce regularly. The hazard of the occasional drouth must be eliminated if possible. It is as crop insurance under such circumstances as these that irrigation can fill a place of economic importance in the state's agriculture. It is not to develop irrigation, often expensive irrigation, for cheap land to reclaim it and make rural homes, but to develop cheap irrigation for high priced lands and thus bring crop production in line with the cost of owning and operating such lands that irrigation performs its proper function.

As a means of providing a water supply to insure crops against the injurious effects of irregularly occurring drouths in a region such as this, pump irrigation is better adapted to the situation than other methods, in that it is cheaper, and comes nearer meeting the requirements of an irrigation enterprise in the semi-humid belt than would great ditch systems such as those in the West.

IRRIGATION PRODUCES RESULTS.

Everywhere that irrigation has been given a reasonable trial the yields of crops have been doubled, or more than doubled. More important still, it has been shown that irrigation practically insures good crop yields each year and relieves the farmer of the hazard of failures or partial failures caused by periods of drouth; and drouth constitutes one of the greatest hazards of agriculture in the entire Great Plains region.

The following table shows briefly the relation between irrigated and unirrigated crops on some Kansas farms where, because a portion of the field was irrigated and a portion not, a direct comparison could be made.

RELATIVE YIELDS OF IRRIGATED AND UNIRRIGATED CROPS.

Name.	County.	Crop.	Yield, bushels.	
			Irrigated.	Unirrigated.
J. E. Lawrence	Rice	Corn	64	16
D. J. Fair	Rice	Corn	55.3	27.8
C. W. Dilley	Rice	Corn	62	23
Schuyler Jones	Sedgwick	Corn	50	1.7
Schuyler Jones	Sedgwick	Corn	47	8
Schuyler Jones	Sedgwick	Corn	44	5.5
Schuyler Jones	Sedgwick	Corn	36	7
Hutchinson Irrigation Association	Reno	Corn	50	5
J. D. Mitchell	Douglas	Corn	71	10
J. M. Hulpieu	Ford	Potatoes	200	30

PUMP IRRIGATION IS CHEAP.

It has also been shown that pump irrigation is cheap. There are very few places in the United States where irrigation canal systems can be built with construction costs under $50 an acre. Most of the notable government projects in the West cost more than that, and there are now under consideration a number of projects, the estimated costs of which range from $100 to $300 an acre. With reference to the proposed Columbia Basin project, Dr. Elwood Mead, commissioner of the United States Bureau of Reclamation, says: "The water right for a single acre will cost $158. To this must be added the cost of changing raw land into farms, which will average $100 an acre." These illustrations are given only to serve as a basis for the comparison of such costs with those of pump irrigation.

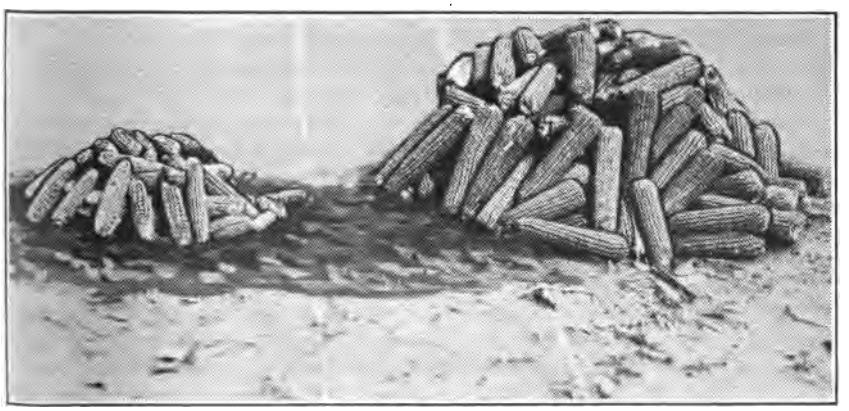
In the Arkansas valley in Kansas to-day, well designed and substantially built, electrically driven pumping plants are being constructed at costs ranging from $10 to $15 per acre for the number of acres the plant is capable of serving. To illustrate these costs in another way: The pumping plant for a

farm of 40 to 80 acres should have a capacity of 750 to 1,000 gallons per minute. It will cost between $800 and $1,000 to construct it. For larger farms, *i. e.*, 80 to 120 acres, the plant should have a capacity of about 1,500 gallons per minute, and should cost about $1,800. If the farm is larger than 120 acres, a supply of not less than 2,000 gallons per minute should be developed, and

DEMONSTRATION PUMPING PLANT OF THE KANSAS STATE FAIR, HUTCHINSON.

the cost will run in the neighborhod of $1.25 to $1.50 per gallon per minute of capacity.

The comparison is still more striking if made with the costs of water rights under established irrigation systems. A pumping plant with a capacity of 1,500 gallons, that is, approximately 3 cubic feet per second, will cost about $1,800, or



CORN ON J. D. MITCHELL FARM, LAWRENCE, 1926.

Not irrigated,
10 bushels per acre.

Irrigated,
71 bushels per acre.

$600 per second-foot of capacity. Under ditch projects of the West, a second-foot is considered adequate for the irrigation of 80 acres of land. Water rights under many of such ditches sell for from $100 to $150 an acre, or $8,000 to $12,000 per second-foot of flow. Around Denver, in recent years, water rights have reached a value as high as $13,000 per second-foot.

Many people are under the impression that, while the construction of pumping plants may be cheap, pumping water for irrigation is expensive, but such is not the case. Pumped water in our river valleys costs but little, if any, more than maintenance and operating charges under a river ditch furnishing its water users a dependable supply of water. Many of the ditches in the upper Arkansas valley find it necessary to make annual maintenance and operating charges of $2.75 an acre. Such charges in the West range from $1.50 to more than $3 an acre annually. With well constructed irrigation plants, the following figures give quite closely the cost of irrigation pumping in the Arkansas valley in Kansas, with a charge of 3½ cents per kilowatt hour for electric energy:

Lift.	Cost per acre-foot of water.	Cost per irrigation.
15 feet	$1.20	40¢ per acre
20 feet	1.60	50¢ per acre
25 feet	2.00	66¢ per acre
30 feet	2.40	80¢ per acre

ADVANTAGES OF PUMPING PLANT

The pumping plant has additional advantages, in that, from the standpoint of its operation, it more nearly meets the peculiar requirements of the farmer of the semihumid belt than a canal or gravity system. From its very nature a long canal functions most satisfactorily and efficiently with continuous use. But conditions in the Great Plains region are not such that continuous operation of an irrigation enterprise is required, nor is continuous operation even desirable. During a considerable portion of the crop-growing season natural precipitation is sufficient for the needs of the crops. Droughts, when they do occur, come on at irregular intervals and sometimes when least expected. This makes it desirable to provide an adequate water supply which can be made available on short notice.

An irrigation canal also requires constant maintenance. This is an item of expense which must be met whether the canal is in use or not, and is a charge which must be figured on during a wet year as well as a dry year, because the problem of keeping a canal free from weeds and ready to operate is a bigger one in a wet season when that canal is not carrying water than when it is. Furthermore, unless the canal does receive sufficient maintenance to keep it ready for use at all times, it utterly fails to meet the very purpose for which constructed—the insurance of crops against drought.

On the other hand, the irrigation pumping plant, if properly constructed, can set unused for long periods of time without falling into such a state of disrepair that it cannot, when needed, be put in service with but little more than an hour's notice. When idle it requires little or no maintenance, unless perhaps it is on an electric line where a monthly service charge is made. And that can often be eliminated or at least reduced by having the transformer plugs pulled when the plant is not in use.

The chief item of cost in the operation of the pumping plant is the actual "cost of pumping," but this expense is incurred only when the farmer is actually using water, while maintenance and operating charges under a ditch go on from year to year, whether there is regular need for the water or not, and whether or not the ditch owns sufficient water so that an adequate amount can be supplied at all times and in all years.

A further advantage of the pumping plant is that by the use of it the farmer enjoys complete independence in the use of water. Under most irrigation ditches water is delivered to the users in one of two ways; either the water user gets a small "head"—perhaps one second-foot—continuously, which he must use, or waste, night and day throughout the season, or a number of farmers are grouped together on one lateral and a larger "head" rotated from one to another of the group. In this case each man must take his water when his turn comes, or lose something he has paid for. In many instances he finds it necessary to take water when he is not ready for it, or to apply it to some crop other than the one he prefers to use it on, because his turn may come at a time when he is putting up a crop of hay or cultivating a field and he is unable to save the water until he has the field ready for irrigation.

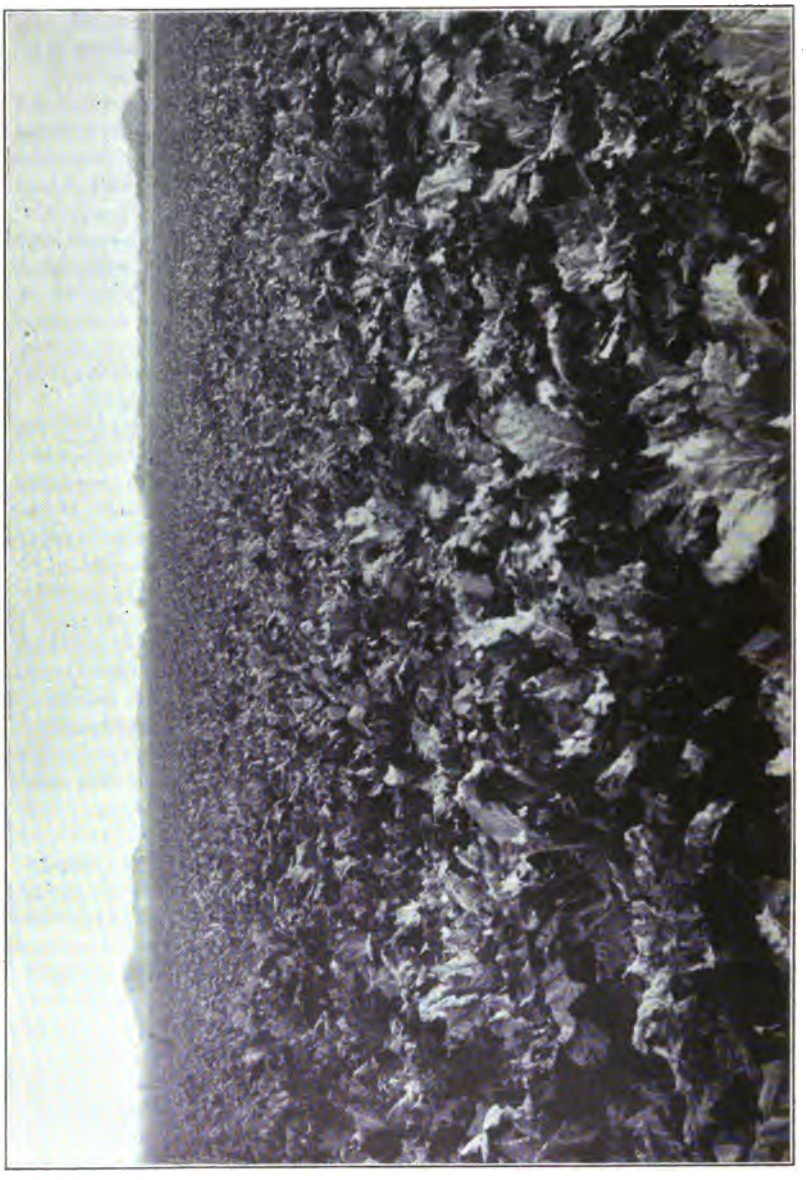
The foregoing has not been said to deprecate or speak disparagingly of the ditch projects of the West, or even to infer that the methods used in the development of their irrigation supplies were not the best adapted to prevailing conditions. The purpose was merely to point out and compare some of the outstanding advantages of pump irrigation for a supplementary water supply for farms in the subhumid belt.

TWO THINGS ESSENTIAL TO SUCCESS.

This work has also emphasized the fact that to be successful the pumping plant must meet two requirements. First, it must be so constructed that it is always ready for use when needed, without undue delay; and second, it must be of such size that the owner can do a reasonable and satisfactory day's work with it. These might seem like minor considerations, yet many people who have tried pump irrigation and failed, have failed solely because they have ignored one or both of these fundamentals.

It has been a popular theory that because the pumping plant is used only occasionally, any kind of a temporary or makeshift installation will serve the purpose. That theory is false. The need for irrigation water comes at unexpected times and often when the farmer is busily engaged in other important work. If it is necessary for him to assemble some equipment into a temporary installation, or make extensive repairs on his plant before he can use it, the probability is that either he will fail to put water on his crop at all, or if he does water it, he will apply the water so late that the crop is already badly damaged, and he declares irrigation is a failure.

The farmer is never expecting a dry season. He may have lost most of his crop last year by drouth, but since there is plenty of moisture in the spring when he is planting, he reasons that this will not be another dry year, and he does not plan for irrigation as a part of his regular summer's work. He seldom realizes that his crop is needing water until it has actually suffered for lack of it. He then waits a few days in the hope of rain. Suddenly it occurs to him that unless he does something at once his crop will be



A FIELD OF IRRIGATED SUGAR BEETS AT THE KANSAS STATE INDUSTRIAL REFORMATORY, HUTCHINSON.

lost. If it is then necessary to gather pump, pipe and other equipment, which during the year has been used in various ways about the place, and assemble all into some kind of a haphazard and temporary installation, the chances are that he gets water on the crop only after it is damaged beyond recovery. He has then spent his time and money, does not get an adequate return, and he says irrigation does not pay.

If, on the other hand, the plant has been properly installed, so that it is always ready to run, there is less reason to procrastinate when the crop is in need of water, and when the farmer does make up his mind to irrigate he can proceed without delay. This gives the pumping plant somewhat the same status as an insurance policy—something provided for in advance of the need for it, forgotten until it is needed, but when needed is ready to serve. Under these circumstances the pumping plant becomes efficient, satisfactory, and effective crop insurance.

The size, or the capacity, of the plant is also a factor in its success or failure. It might seem, perhaps, that in a region where the rainfall is upward of 20 inches, it would not be necessary to provide as large a water supply for a given number of acres as where the rainfall is less than 10 inches, but ordinarily such is not the case. It would be folly to attempt to save an 80-acre field of corn with a pumping plant capable of irrigating but two acres a day. In general those sizes referred to earlier will be found adequate for most farms. It is always necessary to have a plant large enough to provide a satisfactory irrigating "head," and where the plant is small, the labor cost incident to spreading the water may often equal or exceed the cost of pumping it.

FARMER SHOULD HAVE COMPETENT ADVICE.

In the foregoing discussion it is assumed that the farmer had competent engineering advice in the examination of his water supply and the design of his pumping plant.

Developing the water supply has not been reduced to the engineering science to which the design of the pump, motor or engine has been. An engineer can determine with mathematical accuracy the speed at which a given pump should be run to give the highest efficiency, what its capacity will be at that speed, and how much power it will take to operate it under a given head, but the amount of water a well will yield cannot be computed by any process of mathematics, even when all information obtainable is at hand. This fact makes the installation of a successful irrigation plant much more complicated than is generally supposed.

The well system is the heart of the irrigation plant. The success or failure of the entire plant depends upon it. The best grade of machinery, the most careful computations on the size of the pipe, pump and engine, cannot make an irrigation plant successful if the well fails to yield the water expected of it. In most instances it is necessary to buy the machinery before the capacity of the wells has been determined. For efficient operation the pump and power should be properly proportioned to the capacity of the wells. After the machinery has been installed it is then too late to correct errors made by overestimating the water supply.

The first step in the determination of the water supply is to put down a test well at the place where it is proposed to locate the irrigation plant. This

well should be put entirely through all valuable water-bearing formations, and should, if possible, reach an impervious floor. The diameter of the well is not important. It may be any size which the tools at hand make desirable.

The information secured from this test well will show the depth to the water table, the nature of the water-bearing material, whether coarse or fine sand, the thickness of each stratum and the nature of any layers of impervious material which may be encountered. It will furnish information for determining the type of plant best adapted to the conditions, the amount of well casing needed, and the size of the perforations in it. In the hands of experienced men it will also furnish information regarding the probable amount of water the wells will yield. Without the test well the planning of an irrigation plant is a very uncertain proposition. The failure to have a test made before the construction of the plant has been the cause of more unnecessary expense, low efficiency, and general dissatisfaction then any other single element entering into the installation of the plant. Stress is laid on this because of the seeming reluctance of many farmers to have a test made before buying their well casing, pipe and machinery.

When it is known that he intends to put in an irrigation plant the farmer is often besieged with pump salesmen, well men who have their own particular type of well casing to sell, and inventors who are certain they have discovered something which will pump "twice the water with half the power." To rid himself of them the farmer often purchases something against his better judgment and without due consideration of its fitness for his peculiar conditions. In most localities where this condition prevails, we find almost as many different types as there are plants in use. Few of them are efficient, many unsatisfactory, and most of them costing more than well designed plants could be built for.

Since sound engineering principles have been applied to the problem, much has been accomplished towards standardization of types adapted to the requirements of various conditions of lift and water supply. The freak plant has been almost entirely eliminated, and the cost of construction greatly reduced. As an illustration, in the valleys it has become standard practice, where the depth to water is 25 feet or less, to use 16-inch wells spaced 40 feet apart center to center, using as many wells for each plant as will be required to yield the desired amount of water. Sufficient tests have been made of plants of this type, and the yield of such wells studied sufficiently, so that where the log of a well for a prospective pumping plant is available, and the material from the well can be examined enough to classify it as good, medium or poor, the probable yield of the well system, and the pumping head, can be determined, and the pumping plant can then be designed with every assurance that when finished it will do what is expected of it.

CHAPTER II.

THE PROPOSED ARKANSAS RIVER COMPACT.

The controversy over the use of the water of the Arkansas river for irrigation has been referred to from time to time in the biennial reports of the Division of Irrigation. The issues involved were discussed in the 1919-'20 report.

Legislation was enacted in Colorado in 1921 and in Kansas in 1923, providing for an interstate commission and the appointment of commissioners. Meetings of the commissioners began soon after the appointment of the Kansas commissioner in June, 1923. After considerable study and deliberation, the commissioners, in November, 1924, brought out the preliminary draft of a proposed compact. This was submitted to interested parties of both states for criticism and suggestions, and in June of the following year a revised draft was made which is printed here as the proposed compact.

GENERAL PROVISIONS OF COMPACT.

Briefly, the compact provides for a channel reservoir or reservoirs on the Purgatoire river in Colorado to store the surplus waters of that stream for use in Kansas to supplement the amount now received by the Kansas ditches from direct flow.

At the outset it was apparent that the commissioners had a very difficult task on their hands. The natural summer flow of the Arkansas river has been overappropriated for years. The use of water under these appropriations, in most instances, had, through long use, ripened into property rights which could not be taken away without the consent of the vested owners. Because of this the commissioners felt that any attempt to merely allocate or apportion among the various users the available summer water could not solve the problem, since like a court decree, where the victorious litigant secures his water at the expense of the defeated one, it would merely transfer the shortage of water from one locality to another. If the commissioners could accomplish no more than that, the compact method of settling the controversy apparently would have little advantage over allowing the pending suits to be carried to a conclusion in the courts. The commissioners felt that such action would not provide a satisfactory solution, but that a more constructive solution would be for the states involved to jointly construct reservoirs to store additional water, and thus minimize the conflict, and so far as possible leave undisturbed the vested rights in the two states. This meant additional storage on the stream, and storage of the type necessary to equalize the flow of the stream over long periods of time.

An examination of the records of the flow of the Arkansas river at the Kansas-Colorado state line indicated that, notwithstanding the fact that the Kansas ditches are periodically short of water, and that frequently this shortage becomes so acute that crops suffer serious damage, when the average annual flow is consulted it appears that if properly controlled there would be enough water to meet the needs of the Kansas ditches. It does at least suggest the possibility that reservoir control could do much toward a solution of the problem, and among other things a study was undertaken, directed toward finding whether or not sufficient storage could be found to effect the desired control.

While there were two or three small reservoir sites in Kansas, none were channel reservoirs, and none were of the kind necessary to provide the heavy reservoir control required to impound flood waters and equalize the flow of the stream from year to year. In Colorado, the Purgatoire river, the largest tributary of the Arkansas, having its headwaters in the Sangre de Cristo mountains west of Trinidad, and emptying into the Arkansas at Las Animas, about 65 miles west of the interstate line, seemed to offer the most promising solution of the problem. There are four undeveloped channel reservoir sites on that stream in the cañon below Trinidad. Beginning at the upper end of the cañon they are: Mammoth, capacity 178,000 acre-feet; Chauquaqua, capacity 174,000 acre-feet; Purgatoire No. 2, 123,000 acre-feet; I. S., capacity 83,000 acre-feet. It is evident, of course, that the combined storage capacity greatly exceeds the available water on the stream. Information regarding the existence of these sites is of interest, however, in that it shows that additional storage can be built when necessary to offset the accumulation of silt in reservoirs previously constructed. This would be permitted under article II of the proposed compact, which gives Kansas the right to maintain and operate a reservoir, or reservoirs, to a capacity of 120,000 acre-feet. Records of stream-flow on the Purgatoire indicate an average annual flow near the mouth of 98,700 acre-feet for the period 1906 to 1925 inclusive. It appears from a study of these records that with a reservoir of 120,000 acre-feet capacity, nearly 95 per cent of this water can be controlled.

In its present uncontrolled condition, the five Kansas canals, which at one time or another were involved in interstate water litigation, obtain from the Arkansas river by direct diversion during the nine months March to November, inclusive, about 58,500 acre-feet, or somewhat less than one acre-foot per acre. If the provisions of the proposed treaty were carried out, these Kansas ditches could obtain from the Purgatoire reservoir, allowing ten per cent for loss in transit, an average of 62,500 acre-feet annually, or about an acre-foot per acre of land. Considering the value of stored water from the standpoint of the irrigation farmer, the proposed reservoir project is remarkably cheap. The project involves only the construction of a dam, and since the lands, rights of way and easements necessary for the construction and operation of the reservoir would be furnished by Colorado, the actual cost of the dam alone would be borne by the Kansas ditches. Surveys made at the dam site of Purgatoire No. 2 reservoir show that an earth-fill dam would require 960,000 cubic yards of material. It has been estimated that the dam could be built for about $720,000, which would be but a little over ten dollars an acre for the land under the Kansas ditches which would benefit from its construction.

In the beginning the Kansas commissioner enjoyed the coöperation of the interested parties in Kansas. Later a lack of interest was shown, and when in addition to this lack of interest, the plaintiffs in the present interstate suits expressed distrust in the project, the matter was laid aside until sufficient interest in it is shown to justify further work on it.

The proposed Arkansas river compact follows:

THE ARKANSAS RIVER COMPACT.

The state of Colorado and the state of Kansas desiring to provide for the division and control of the waters of the Arkansas river and to remove all causes of present and future controversy, between said states and between citizens of Kansas against citizens of Colorado, to the waters of said river, and being moved by considerations of interstate comity, pursuant to acts of their respective legislatures have resolved to conclude a compact or treaty for these purposes and have named as their commissioners, Delph E. Carpenter, for the state of Colorado, and George S. Knapp, for the state of Kansas, who have agreed upon the following articles:

ARTICLE I.

Where used in this compact, singular words shall be construed as including the plural, masculine words shall be construed as including the feminine and neuter, and the following terms and expressions shall have the following meanings respectively:

(1) The state of Colorado and the state of Kansas are designated, respectively, as "Colorado" and "Kansas."

(2) "Direct diversions" are those diversions of water from a stream, by means of ditches, canals or other appliances, whereby such waters are carried to the land for irrigation without storage.

(3) "Storage of water" is the impounding thereof in reservoirs for use subsequent to the time of the impounding.

(4) "Purgatoire cañon" means that portion of the cañon of the Purgatoire river in the state of Colorado situate between the point where said river enters a cañon immediately below the junction of the Purgatoire river and San Francisco creek in township 33 south, range 60 west, in Las Animas county, Colorado, and continuing thence in a northeasterly direction through portions of Las Animas, Otero and Bent counties to the Highland dam.

(5) The "Highland dam" is the diversion dam across the channel of Purgatoire river in section 1, township 25 south, range 52 west, sometimes designated as the Carman dam, heretofore constructed and used for the diversion of waters from the Purgatoire river in the principal canal of the Highland Irrigation District, the lands of which are situate between said dam and the Arkansas river.

(6) "Purgatoire reservoirs" means the reservoir or reservoirs which Colorado consents Kansas may build and hereafter operate in the Purgatoire cañon.

(7) "Final approval" of this compact means the date of the approval thereof by the congress of the United States, following its approval by the legislatures of the signatory states.

(8) "Interstate line" means the boundary line between the state of Colorado and the state of Kansas.

ARTICLE II.

Colorado grants to Kansas the right to construct and thereafter maintain and operate storage reservoir or reservoirs in the Purgatoire cañon to a maximum safe storage capacity of 120,000 acre-feet, which may include the site or basin of the Mammoth reservoir situate at the head of the Purgatoire cañon, subject to the following reservations and limitations and upon the following conditions which are and shall be limitations upon and conditions running with the rights and privileges hereby granted:

(1) Colorado agrees to acquire and to place at the disposal of Kansas the lands, rights of way and easements necessary for the construction and operation of such of said reservoirs as Kansas may select and designate, upon the express condition, however, that such designation shall be made within five years from the date of final approval of this compact, by written notice by the governor of Kansas to the governor of Colorado, and should Kansas fail so to select and designate such site or sites within said five-year period, Colorado shall be relieved of the duty of acquiring such lands, rights of way and easements for Kansas.

(2) Kansas shall commence the construction of such reservoir or reservoirs within fifteen (15) years from the date of the final approval of this compact, and shall complete such reservoirs within twenty-five (25) years from said date. The grant hereby made to Kansas shall terminate and revert to Colorado with respect to any of the Purgatoire reservoirs so selected by Kansas but which have not been constructed within 25 years from the date of final approval of this compact: *Provided, however,* That Kansas thereafter shall have the right to construct other reservoirs on said cañon at any site or sites remaining available, to a capacity sufficient to replace storage lost through the deposition of silt in reservoirs already constructed.

(3) Colorado grants to Kansas the right to acquire by purchase, prescription or the exercise of eminent domain, such rights of way, easements or lands as may be necessary for the construction, maintenance and operation of the reservoir or reservoirs provided for in subparagraph 2 of this article.

(4) Kansas shall comply with the laws of the state of Colorado relating to the approval of plans and specifications for reservoir dams, the inspection and supervision of the construction thereof and the safe operation and use thereof after completion.

(5) Such reservoir or reservoirs shall be and remain free from corporation, property and other taxes and assessments in Colorado, so long as the same shall be used by Kansas.

ARTICLE III.

Colorado grants to Kansas the right to store in the reservoirs provided for in article II, the waters of the Purgatoire river, with the following exceptions and reservations and upon the following conditions and limitations which are and shall be reservations, conditions and limitations running with the grant, hereby made, to wit:

(1) Water necessary to supply direct diversions made above the head of Purgatoire cañon in Colorado: *Provided, however,* That water so diverted shall be used exclusively upon lands within the drainage area of the Purgatoire river;

(2) Water necessary to supply all present constructed reservoirs, and reservoirs which may hereafter be constructed above the Purgatoire cañon to an additional maximum aggregate storage capacity of not to exceed 10,000 acre-feet: *Provided, however,* That the waters stored in any of such reservoirs shall be used exclusively within the drainage area of the Purgatoire river;

(3) Water necessary to supply present and future municipal and domestic needs in the drainage area of the Purgatoire river;

(4) Water necessary to supply direct diversions for the irrigation of lands in the Purgatoire cañon and in tributary cañons and draws;

(5) Water necessary to permit the Highland Irrigation District to enjoy its present decreed appropriations up to the amount actually required for the irrigation of the ——— acres included in the Highland Irrigation District; and

(6) For the benefit of Colorado appropriators diverting from the Arkansas river below the mouth of the Purgatoire river, 10,000 acre-feet from the water flowing into said reservoirs in each calendar year or that part of said amount which may have flowed into said reservoirs during any year, said water to be discharged in quantities and times upon demand made by the Colorado water official having jurisdiction of the diversion and distribution of water in the Arkansas valley in Colorado and to be by him apportioned among the several appropriators diverting from the Arkansas river at points between the mouth of the Purgatoire and the interstate line, ratably according to the decreed appropriations held by said appropriators on the date of this compact, which said delivery of water from said reservoir shall constitute full satisfaction of any and all claims upon the waters of the Purgatoire river by all Colorado appropriators diverting from the main Arkansas river.*

* The commissioner for Kansas objects to paragraph six for the reason that since Colorado diverts more than 1,000,000 acre-feet annually from the main stream the loss of 10,000 acre-feet of Purgatoire river water could not be felt if distributed over the river, while the loss of that amount annually from the Purgatoire reservoir during a series of dry years might make storage on that stream of questionable benefit to Kansas.

ARTICLE IV.

(1) The Purgatoire reservoirs shall at all times be under the control of Kansas, subject to Colorado law as provided in article II.

(2) The channel of the Purgatoire river and the channel of the Arkansas river from the mouth of the Purgatoire to the interstate line are hereby constituted a carrier for conducting water, designated as "water in transit," which has been stored in the Purgatoire reservoirs in accordance with the terms of this compact: *Provided, however,* That the channels of said streams shall not be burdened with the carriage of such water above ordinary high water mark.

(3) The officials of Colorado having charge of the administration and the diversion and distribution of the waters of the Arkansas river, shall protect Kansas in the use and operation of said reservoirs, and shall supervise the carriage of waters therefrom through the channels of the Purgatoire and Arkansas rivers and the delivery thereof at the interstate line, less proper deductions for natural losses in transit. All withdrawals and carriage of water from said reservoirs to the interstate line shall be in conformity with the rules and regulations provided for in paragraph 4.

(4) The state engineer of Colorado and the state irrigation commissioner of Kansas, by agreement from time to time, shall formulate rules and regulations for carrying out the provisions of this contract, which, when signed and promulgated by them, shall be binding until amended by agreement between them or until terminated by written notice from one to the other.

(5) Said officials shall determine the losses incident to the flow of water from the Purgatoire reservoirs to the interstate line, and in the event said state officials disagree with respect to such losses, they shall select a third engineer, who, with such officials, shall constitute a board for the determination of such losses, and the decisions of such board shall be conclusive upon both states. The compensation and expense of the third member of such board shall be paid equally by the two states. Pending the determination of such losses, an arbitrary deduction of 10 per cent shall be charged against all runs of water from the reservoirs to the interstate line.

ARTICLE V.

(1) It is the desire of Kansas to permit its citizens to construct the Medway reservoir to be located in township 23 south, range 42, west of the sixth P. M., in Hamilton county, Kansas, a portion of the inlet canal and diversion works for the supply of which will be located in the vicinity of the Buffalo canal in Colorado, and to use said reservoir and inlet appliances for the diversion of water from the Arkansas river in Colorado and the carriage thereof into Kansas. With respect thereto it is agreed:

(*a*) Colorado consents that Kansas and its citizens may hereafter construct, maintain and operate such canal and diversion works in Colorado, and grants to Kansas and its citizens the right to acquire by purchase, prescription or the exercise of eminent domain such rights of way, easements or lands as may be necessary for the construction, maintenance and operation of said canal and diversion works, subject, however, to the reservations, limitations and upon the conditions expressed in this article, which are and shall be limitations upon and reservations and conditions running with the rights and privileges hereby granted.

(*b*) Waters stored in the Purgatoire reservoir by Kansas may be diverted by such inlet canal and carried to said Medway reservoir in lieu of carriage in the channel of the Arkansas river to the state line, and said inlet canal may be used for the diversion and carriage of such of the waters of the Arkansas river as would otherwise pass into Kansas after satisfying all present and future demands upon said stream in Colorado: *Provided, however,* That the diversion of water by said canal shall not encroach upon the rights or water supplies of present existing canals of Kansas, and shall not vest in Kansas or those in control of said canal or in the users of water therefrom any prior, preferred or superior servitude upon or claim or right to the use of any water of the Ar-

kansas river in Colorado as against any present or future appropriator or user of water from said river in Colorado, and Kansas agrees no such claims will ever be made or asserted.

(c) Kansas shall have the right to regulate diversions of water by said canal for the purpose of protecting other diversions from the Arkansas river within Kansas and of diverting and conveying waters discharged from the Purgatoire reservoirs for carriage into Kansas, but Colorado reserves the right at all times to control and regulate the diversions by said canal to the extent necessary for protection of users in Colorado.

(2) Colorado hereby disclaims jurisdiction over the Frontier canal, which diverts water from the Arkansas river immediately above the interstate line and irrigates lands wholly in Kansas, and Colorado concedes to Kansas sole jurisdiction over said canal and the diversions of water thereby to the same extent as though said canal and works were located and the diversions of water made wholly within the state of Kansas.

ARTICLE VI.

(1) Kansas agrees that compliance by Colorado with the provisions of this compact shall relieve Colorado from any further or additional demand or claim by Kansas upon the waters of the Arkansas river within Colorado.

(2) Upon final approval, this compact shall be entered as the decree in all suits, now pending in the United States district court for the district of Colorado, between users of water from the Arkansas river in Kansas and Colorado.

ARTICLE VII.

In connection with each and every development made under the provisions of this compact, there shall be installed and maintained all equipment and apparatus essential for measuring quantities and rates of water flow, the determination of which may be necessary for the purpose of showing that the development or constructions is being operated in compliance with the provisions of this compact.

ARTICLE VIII.

Any administrative department, political subdivision, corporation, association, partnership or person authorized in that behalf by or under the laws of a signatory state may exercise the rights and privileges herein conferred on such state subject to the duties and obligations herein imposed on such state.

ARTICLE IX.

When any official of either state is designated to perform any duty under this compact, such designation shall be construed to include the state official or officials upon whom the duties now pertaining to such official may hereafter devolve, and it shall be the duty of the officials of Colorado, charged with the distribution of the waters of the Arkansas river, to carry out the terms and provisions of this compact, without the necessity of enactment of special statutes for such purposes by the general assembly.

ARTICLE X.

The physical and other conditions peculiar to the Arkansas river and the territory drained and served thereby constitute the basis for this compact, and neither of the signatory states hereby concedes the establishment of any general principle or precedent with respect to other interstate streams.

ARTICLE XI.

The provisions of this compact respecting each signatory state shall include and bind its inhabitants, citizens and corporations and all those engaged or interested in the diversion and use of the waters of the Arkansas river in that state.

ARTICLE XII.

Should any claim or controversy arise between the signatory states with respect to the meaning or performance of any of the terms of this compact, or in case it should become desirable to modify any provision or all of this compact, then the governor of each state, upon request of the governor of either state, shall forthwith appoint a commissioner empowered to jointly consider and adjust such claim or controversy or to recommend such modification, subject to ratification by the legislatures of the signatory states and the consent and approval of the congress of the United States.

ARTICLE XIII.

Nothing in this compact shall be construed to limit or prevent the institution or prosecution of any proceedings in any court of competent jurisdiction for the purpose of compensating, remedying or correcting by damages, injunction, mandamus or other process, civil or criminal, any act of commission or omission in violation of the provisions of this compact, for the protection of any rights under it, for the enforcement of any of its provisions, or for the awarding or enforcement of payment for compensation of any injury which may be caused by the exercise of any right or privileges herein authorized.

ARTICLE XIV.

This compact may be terminated at any time by the legislative action of the signatory states. In the event of the termination of this compact all rights and obligations which may have become established or vested under its provisions shall remain and continue uninterrupted. Said termination shall be subject to such terms and conditions as may be agreed to by said signatory states.

ARTICLE XV.

This compact shall be operative when approved by the legislature of each of the signatory states and by the congress of the United States. Notice of approval by the legislature shall be given by the governor of each state to the governor of the other state and to the President of the United States, and the President of the United States is requested to give notice to the governors of the signatory states of the consent and approval by the congress of the United States.

In Witness Whereof, The commissioners have signed this compact in duplicate originals, one of which shall be deposited with the secretary of state of each of the signatory states.

Done at ———, in the state of ———, in the year of our Lord one thousand nine hundred and ———.

NOTE.—The above is a proposal for compact between the states of Colorado and Kansas respecting the diversion and control of the waters of the Arkansas river. It is now offered for examination, study and criticism by counsel and other interested parties in both states.

(Signed) DELPH E. CARPENTER.
(Signed) GEO. S. KNAPP.

DENVER, COLO., July 24, 1925.

CONDITIONS OF WATER SUPPLY.

While it is not possible, in this report, to publish more than a small portion of the statistical information assembled and used by the commissioners, it does seem desirable to publish enough to show the amount of water available for the Kansas ditches under present conditions, the amount of water available on the Purgatoire, and the amount which it is calculated could be stored on that stream and controlled by the construction of the Purgatoire No. 2 reservoir, previously referred to.

Table I gives the flow of the Arkansas river near the Colorado-Kansas state line. Records prior to 1921 are from the Colorado station at Holly, and those after that date are from the Kansas station at Syracuse.

Table II shows the discharge of the Purgatoire river near its mouth for the 20-year period ending with 1925. The records for some years have been fragmentary, and where such is the case, calculations have been made by expanding the records of measured run-off through a comparison with precipitation records in order to reach a probable discharge for the entire period. In this connection it should be noted that about 77 per cent of the annual run-off occurs during the five summer months May to September, inclusive, and that records are practically complete for those periods.

The United States Weather Bureau has maintained, within the drainage area of the Purgatoire, rainfall stations at Trinidad, Madrid, Hoehne, Stonewall and North Lake. Table III shows the average of all available records from these five stations for the 20-year period ending with 1925.

TABLE I. Discharge, in acre-feet, of the Arkansas river near the Colorado-Kansas state line, 1911 to 1924, inclusive.
(Record from 1911 to 1920 from Colorado station at Holly; 1921 to 1924 from Kansas station at Syracuse.)
Amounts in acre-feet.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals.	
1911	3,293	3,269	3,933	1,005	8,289	2,011	33,495	2,725	292	3,388	20,582	24,904	107,000	
1912	.....	20,837	25,264	8,216	1,047	36,659	6,354	67,299	14,406	6,143	11,540	.....	198,000	(10 mo.)
1913	30,700	24,700	14,000	1,910	357	9,400	19,600	1,080	833	885	1,330	10,600	115,000	
1914	14,000	8,780	3,980	2,430	166,000	189,000	97,200	54,800	1,530	3,940	5,030	.....	547,000	(11 mo.)
1915	13,500	11,200	16,100	69,600	79,300	146,000	23,500	98,400	12,900	6,090	7,140	12,000	496,000	
1916	18,100	28,100	5,600	4,160	572	7,140	781	48,200	9,100	3,850	8,690	.....	134,000	(11 mo.)
1917	16,500	9,550	5,920	595	912	1,670	2,370	4,520	4,400	2,950	1,390	4,140	54,500	
1918	6,330	4,550	4,870	2,010	1,680	5,740	7,990	2,560	6,310	2,900	5,180	8,730	59,200	
1919	.....	.....	21,200	80,900	29,100	3,060	9,220	22,900	4,280	5,570	16,200	20,200	213,000	(10 mo.)
1920	18,400	9,890	4,450	5,210	5,610	2,960	29,100	49,600	25,600	19,100	13,700	15,600	199,000	
1921	.....	.....	9,650	3,660	1,330	510,000	187,000	148,300	9,360	5,890	6,920	20,060	902,000	(10 mo.)
1922	14,350	20,340	11,360	10,510	8,010	1,388	1,245	7,139	274	265	2,990	7,600	85,500	
1923	5,460	7,760	5,320	602	32,000	98,200	83,300	249,000	102,000	147,000	56,800	41,000	828,000	
1924	70,700	58,200	34,700	66,100	17,400	37,200	2,100	1,080	776	2,940	4,370	15,000	311,000	

TABLE II. Annual discharge of Purgatoire river.

Figures in bold-face type are from discharge records. Figures in light-face type are computed from rainfall records, and are based on the assumption that the discharge for each month bears the same relation to average flow that the rainfall bears to the average for the same month.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals.
1906	**2,000**	**1,100**	**600**	**1,500**	**407**	**2,570**	**34,100**	**4,610**	**7,920**	**1,800**	4,200	1,400	62,200
1907	**345**	**477**	**16**	**1,000**	**8,800**	**33,800**	**21,400**	**10,900**	**3,280**	**1,200**	3,070	1,520	85,800
1908	1,260	1,580	487	5,960	3,340	4,420	**26,700**	**28,200**	**1,750**	4,800	4,880	254	83,600
1909	2,220	310	1,200	7,560	**2,890**	**22,600**	**27,800**	**32,100**	**53,400**	1,790	**1,500**	1,750	155,000
1910	920	1,190	293	**29,400**	**8,160**	**25,600**	13,200	13,050	1,780	5,280	1,140	413	77,400
1911	570	1,510	369	945	**5,700**	6,150	**19,800**	**1,860**	**298**	**2,310**	**1,050**	2,160	42,700
1912	500	1,960	1,670	4,870	**10,600**	**33,300**	**11,000**	**7,430**	**12,000**	3,960	1,590	860	89,700
1913	1,150	1,690	**1,500**	**615**	**238**	**8,060**	**1,670**	**128**	11,100	**665**	2,610	2,500	31,900
1914	1,270	425	1,400	**358**	**59,900**	**22,900**	**89,800**	**26,400**	**442**	**325**	**0**	1,140	204,000
1915	1,810	1,190	**2,000**	**30,900**	**61,900**	**30,300**	**15,900**	**23,000**	**1,410**	**1,900**	**1,410**	2,540	174,000
1916	770	476	2,370	14,000	1,910	**258**	**280**	**30,450**	**20**	6,720	2,670	1,600	61,500
1917	1,310	**825**	1,120	8,290	17,800	**144**	**7,150**	**11,350**	9,420	2,070	2,040	**286**	61,800
1918	5,280	1,480	4,170	5,130	1,130	**3,600**	21,400	**7,300**	**8,310**	7,670	5,500	8,900	79,900
1919	310	1,780	4,370	11,500	15,400	**7,340**	**20,600**	**13,000**	12,600	8,050	7,150	1,430	104,000
1920	730	1,530	749	1,200	**6,740**	**5,200**	**7,500**	**17,300**	**8,470**	18,300	1,360	2,100	71,200
1921	1,380	**966**	1,620	6,980	**5,500**	**18,900**	**19,600**	**20,700**	**2,580**	**1,490**	**3,610**	**1,230**	84,600
1922	370	760	2,360	**1,390**	**1,090**	2,710	**7,500**	**4,160**	**440**	**490**	**1,270**	**1,670**	24,200
1923	**2,020**	**1,330**	**1,000**	**504**	**3,180**	**62,500**	**50,800**	**166,000**	**33,900**	**49,200**	**13,700**	**6,270**	390,000
1924	**900**	**1,000**	**3,500**	**15,000**	**5,980**	**2,670**	**3,790**	**3,630**	**175**	**518**	**910**	**984**	39,100
1925	**615**	**833**	**1,080**	**537**	**699**	**2,610**	**27,700**	**11,800**	**1,220**	**1,680**	**2,040**	**1,790**	51,000
Mean	1,290	1,120	1,590	7,380	11,100	13,600	21,400	21,700	8,530	6,010	3,040	2,000	98,700

TABLE III. Average monthly rainfall at Trinidad, Madrid, Hoehne, Stonewall and North Lake, Colo.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1906.....	0.31	0.37	1.17	1.79	1.64	1.57	5.76	1.36	2.10	2.09	0.74	0.44	19.34
1907.....	.09	.37	.01	2.18	3.11	.76	3.56	2.69	.25	.88	.54	.48	14.92
1908.....	.33	1.23	.30	1.64	.42	.35	4.46	2.10	.33	1.02	.86	.08	13.12
1909.....	.58	.24	.74	2.08	1.89	.90	2.23	3.10	2.98	.38	1.73	.55	17.40
1910.....	.24	.92	.18	2.93	1.27	.37	2.06	1.45	.27	1.12	.20	.13	14.35
1911.....	.15	1.17	.22	.26	1.12	.65	4.46	1.94	.92	2.44	.89	.68	14.90
1912	.13	1.52	1.03	1.34	1.72	3.70	2.80	1.76	.75	.84	.28	.27	16.14
1913.....	.30	1.31	.61	1.42	.76	4.00	1.50	1.84	1.69	1.00	.46	3.06	17.95
1914.....	.33	.33	.86	3.68	2.65	1.92	6.27	2.53	.41	1.86	.00	.36	21.20
1915.....	.47	.92	.77	5.06	2.70	1.25	3.60	3.40	.79	.64	.13	.80	20.53
1916.....	1.15	.37	1.46	3.85	.24	.61	2.45	3.19	.22	1.43	.47	1.98	17.15
1917.....	.34	.64	.69	2.28	2.24	.44	1.55	2.58	1.43	.44	.36	.89	13.08
1918.....	1.38	1.15	2.56	1.41	.14	.81	3.52	1.91	3.13	1.63	.97	1.28	19.89
1919.....	.08	1.38	2.69	3.17	1.94	1.63	5.67	1.42	1.93	1.71	1.26	.45	23.33
1920.....	.19	1.19	.46	1.41	.95	1.46	2.48	2.84	1.33	3.90	.24	.66	17.11
1921.....	.36	.75	1.00	1.92	1.94	3.05	3.65	3.39	.46	.48	.04	.68	17.72
1922.....	.08	.59	1.45	1.73	1.91	1.95	3.66	1.25	1.57	.16	1.32	.28	15.95
1923.....	.05	.88	1.49	.91	.55	3.30	3.33	7.22	3.45	.....	.49	1.11	22.78
1924.....	.13	.38	1.99	1.84	.91	.17	1.12	.95	.56	.81	.21	1.75	10.82
1925.....	.52	.85	.13	.30	2.29	.69	3.94	4.31	.....	.....	.....	.....	.....
Mean...	.36	.83	.99	2 06	1.52	1.48	3.40	2.56	1.29	1.27	.59	.80	.....

In order to reach some conclusion as to the amount of water which could be stored in Purgatoire No. 2 reservoir and made available under the terms of the proposed compact, R. I. Meeker and Geo. S. Knapp, engineers for Colorado and Kansas respectively, prepared the information shown in Table IV.

In these computations, they have used the Purgatoire discharges shown in Table II, and have assumed that the Kansas ditches would make an annual demand on this reservoir of 75,000 acre-feet, to be released as follows: 13,000 acre-feet in June, 31,000 acre-feet in July, and 31,000 acre-feet in August, of each year. The Highland canal on the Purgatoire in Colorado would be entitled to demand a total of 3,500 acre-feet per annum, 350 to be released in April, 525 in May, 1,050 in June, 875 in July, 525 in August, and 175 in September. Evaporation losses were computed monthly throughout the period, the amounts of evaporation in acre-feet per acre of water surface area for each month being those given in Table V.

The inserted chart shows graphically the same information given in Table IV:

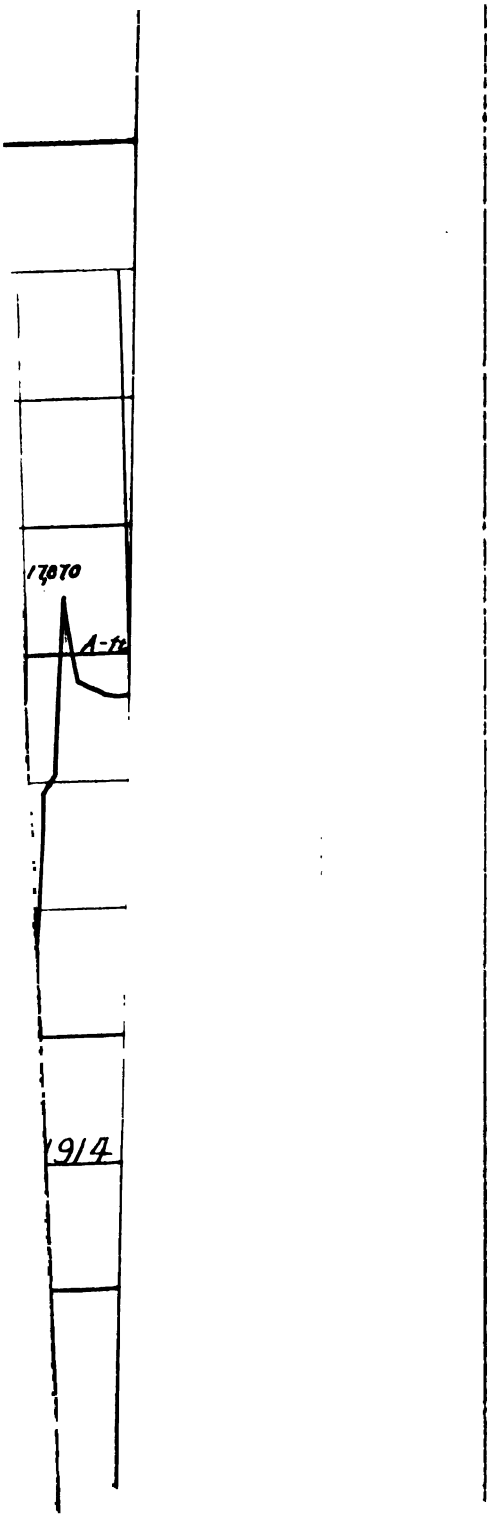
TABLE IV. Computed operation Purgatoire reservoir, 1906 to 1925.

Year.	Inflow.	Kansas demand.	Highland canal demand.	Reservoir evaporation.	Total draft.	Reservoir content at end of year.	Overflow.	Shortage.
1906	62,200	75,000	3,500	1,033	79,533	14,607	.....	34,043
1907	85,800	75,000	3,500	4,552	83,052	17,363	.....	.....
1908	83,600	75,000	3,500	4,012	82,512	18,488	.....	.....
1909	155,000	75,000	3,500	8,415	86,915	86,693	.....	.....
1910	77,400	75,000	3,500	18,054	96,544	67,535	.....	.....
1911	42,700	75,000	3,500	10,230	88,739	21,519	.....	.....
1912	89,700	75,000	3,500	6,103	84,700	26,656	.....	.....
1913	31,900	75,000	3,500	3,470	50,445	16,043	.....	39,431
1914	204,000	75,000	3,500	16,783	95,283	107,240	17,870	.....
1915	174,000	75,000	3,500	22,664	101,164	90,221	90,115	.....
1916	61,500	75,000	3,500	15,076	93,576	58,169	.....	.....
1917	61,800	75,000	3,500	12,018	88,718	31,256	.....	.....
1918	79,900	75,000	3,500	5,089	83,689	29,625	.....	2,188
1919	104,000	75,000	3,500	7,712	86,212	46,953	.....	.....
1920	71,200	75,000	3,500	6,588	85,098	33,034	.....	.....
1921	84,600	75,000	3,500	7,169	85,669	31,921	.....	.....
1922	24,200	75,000	3,500	3,235	81,735	3,618	.....	29,222
1923	390,000	75,000	3,500	13,220	91,720	120,000	182,302	.....
1924	39,100	75,000	3,500	17,586	96,086	45,139	17,832	.....
1925	51,000	75,000	3,500	5,881	84,381	11,792	.....	.....

TABLE V. Reservoir evaporation in eastern Colorado.

(From page 135, eighteenth biennial report state engineer of Colorado, 1915-'16.)

Month.	Values in acre-feet per acre surface area.	Month.	Values in acre-feet per acre surface area.
January	0.16	August	0.71
February	0.17	September	0.60
March	0.28	October	0.36
April	0.43	November	0.24
May	0.51	December	0.15
June	0.63		
July	0.77	Total	5.01


1914

BRIEF ON LAW OF INTERSTATE COMPACTS.

By Delph E. Carpenter.

POWERS OF STATES TO ENTER INTO COMPACTS.

Compacts or agreements between the states are recognized by article I, section 10, paragraph 3, of the constitution of the United States, which provides: "No state shall, without consent of congress, . . . enter into any agreement or compact with another state. . . ."

Interstate controversies and differences respecting boundaries, fisheries, etc., have been frequently settled by interstate compact.

Among the many boundary disputes so settled may be mentioned the following: Virginia and Pennsylvania, 1780 (11 Pet. 20); Virginia and Pennsylvania, 1784 (3 Dall. 425); Kentucky and Tennessee, 1820 (11 Pet. 207); Virginia and Tennessee, 1802 and 1856 (148 U. S. 503, 511, 516); Virginia and Maryland, 1785 (153 U. S. 155, 162).

Of the compacts between states respecting the taking of fish in rivers forming the boundary between the two disputant states may be mentioned: Washington and Oregon, Columbia river; Maryland and Virginia, Potomac river. (153 U. S. 155.)

New York and New Jersey by interstate compact have established their port authority and have settled all differences between them respecting New York harbor. Pennsylvania, New York and New Jersey have settled the Delaware river controversy by compact. The compact between Colorado and Nebraska respecting the equitable distribution of the waters of the South Platte river has been approved by congress and likewise the compact between Colorado and New Mexico respecting the La Plata river. The Columbia river states are negotiating a compact under authority of congress. The seven Colorado river states concluded a compact at Santa Fe in 1922. Colorado, Nebraska, and Wyoming are about to conclude a compact respecting the North Platte river. Wyoming and South Dakota are authorized by congress to conclude a compact respecting the Belle Fouche, and the interstate treaty method of settling disputes and providing for the future use and disposition of the waters of interstate rivers has become an established national and interstate policy.

While all compacts which would in any way involve the federal government or its jurisdiction, property, etc., must be made with consent or approval of congress in order to be binding, it has been suggested by the supreme court that compacts made between two states respecting matters in which the states alone are interested might be taken as binding without consent or approval by congress. (*Stearns v. Minnesota*, 179 U. S. 223, 245; *Virginia v. Tennessee*, 148 U. S. 503; *Wharton v. Wise*, 153 U. S. 155.)

For a full discussion respecting the rights of the states to enter into treaties or compacts, with consent of congress, see *Rhode Island v. Massachusetts*, 12 Pet. 657, 725-731.

In the case just cited the supreme court observed that when congress has given its consent to two states to enter into a compact or agreement, "then the states were in this respect restored to their original inherent sovereignty; such consent, being the sole limitation imposed by the constitution, when

given left the states as they were before, as held by this court in *Poole v. Fleeger,* 11 Pet. 209, whereby their compacts became of binding force, and finally settled the boundary between them, operating with the same effect as a treaty between sovereign powers. That is, that the boundaries so established and fixed by compact between nations, become conclusive upon all the subjects and citizens thereof, and bind their rights, and are to be treated to all intents and purposes, as the true real boundaries. . . . The construction of such a compact is a judicial question," for the United States supreme court. (12 Pet. 725.)

See, also, discussion of the same subject in *Stearns v. Minnesota,* 179 U. S. 223; *Virginia v. Tennessee,* 148 U. S. 503, 517, 528; *Wharton v. Wise,* 153 U. S. 155.

In other words, the states of the Union, by consent of congress, have the same power to enter into compacts with each other as do independent nations, upon all matters not delegated to the federal government.

INTERSTATE COMPACTS RESPECTING USE OF WATERS OF INTERSTATE RIVERS.

While, as we have already observed, various of the states have settled their controversies respecting boundaries, fisheries, etc., by interstate compact or by concurrent state legislation having the same effect, this method of settlement of pending or threatened controversies respecting the use and distribution of the waters of interstate streams for irrigation and other beneficial purposes has not been availed of. The rights of adjoining states to the use and benefit of the waters of the streams common to both states has been considered by the court in the case of *Kansas v. Colorado,* 185 U. S. 125; 206 U. S. 46, in which case it was held that the respective states were each entitled to an equitable portion of the waters of the common river, the extent of the use in each state to be determined upon the facts and circumstances of each particular case.

In the above-mentioned case the right of the United States to the use of the waters of the Western streams was also considered and determined (pp. 87-93).

An equitable apportionment or allocation of the use and distribution of the waters of Western interstate streams may be best accomplished through the efforts of the states represented by commissioners fully acquainted with the facts and the surrounding conditions, as well as with the future possibilities of use of water from the streams.

Principles of international law are applicable to the use and distribution of waters of interstate streams, and as regards compacts between the states, "the rule of decision is not to be collected from the decisions of either state, but is one, if we may so speak, of an international character." (*Marlett v. Silk,* 11 Pet. 1, 23.)

The rights of the nation in whose territory an international stream has its rise to the use and benefit of its waters for the development of its territory, irrespective of the effect upon the territory of a lower nation through which the stream passes on its way to the sea, were fully considered by Attorney-general Judson Harmon, with respect to the claims made by the Republic of Mexico to damage by depletion of the waters of the Rio Grande, occasioned by uses in the United States. After exhaustive consideration of the various

authorities upon the subject, he arrived at the conclusion that, while the United States had the right to utilize the entire flow of the Rio Grande in the necessary reclamation of the lands near the source of the stream, and while "precedents of international law imposed no liability or obligation upon the United States" to permit any of the water of the stream to flow to El Paso, nevertheless, he advised that the matter be treated as one of policy and settled by treaty with Mexico. (21 Ops. Atty.-gen., 274, 280-283.)

It is safe to predict that most of the past controversies respecting the waters of Western interstate streams could have been avoided had the matters in dispute been first submitted to competent compact commissioners. Friction between the federal departments and the state authorities should be avoided by proper compacts between the states before construction proceeds upon rivers where such controversies may arise.

In fact, settlement of possible interstate controversies by interstate compacts is recommended by the United States supreme court. (*Washington v. Oregon,* 214 U. S. 205, 218.)

CHAPTER III.

STREAM-FLOW MEASUREMENTS.

The department has maintained the same gaging stations operated during the water year ending September 30, 1924. These consist of three stations on the Arkansas river, one on the Pawnee river, and five on the five principal irrigation canals taking water from the Arkansas river. The stations on the Arkansas river are located at Syracuse, Garden City and Larned. The station on the Pawnee river is also at Larned. These stations are all equipped with automatic recorders which make continuous records of the gage heights of the water passing the gages.

The gages on the Arkansas at Garden City and Larned, together with the one on the Pawnee river, were installed by the irrigation commissioner and the United States Geological Survey in coöperation with the Kansas Water Commission. The irrigation commissioner furnished the well and shelter, while the United States Geological Survey and the Kansas Water Commission furnished the recording instruments for the gages at Garden City and Larned, and the entire installation on the Arkansas river at Larned. Gages at the coöperative stations are being maintained by the Division of Irrigation, and discharge measurements, for the most part, are made by this department.

ARKANSAS RIVER AT SYRACUSE.

Location. At highway bridge half a mile south of Syracuse, in section 18, township 24 south, range 40 west.

Drainage area. Approximately 25,500 square miles.

Records available. June 20, 1921, to September 30, 1926.

Gage. Gurley automatic graphic water-stage register on downstream side of bridge pier, and staff gage on outside of gage well.

Discharge measurements. Made from bridge during high water and by wading at low stages.

Channel. Shifting.

Extremes of discharge. Maximum stage recorded, 6.35 feet, August 23, 1923 (discharge, 18,000 second-feet); maximum during the biennium, 4.70 feet, July 24, 1925 (discharge, 10,900 second-feet); minimum stages, 0.76 feet, several days in August, 1926 (discharge, 2 second-feet).

Ice. Stage-discharge relation probably affected somewhat by ice.

Diversions. There are court decrees for the diversion of approximately 12,825 second-feet from the Arkansas and its tributaries above this station in Colorado, and two small diversions above it in Kansas.

Accuracy. Rating curve fairly well defined between stages of 0.93 and 5.22 feet. Daily discharge ascertained by applying mean daily gage heights to rating curve. Records fair.

DISCHARGE MEASUREMENTS of Arkansas river at Syracuse, 1924-'26.

DATE.	Made by—	Gage height.	Discharge.
1924.		Feet.	Sec.-ft.
Nov. 10	Verne W. Stambaugh	1.43	76.8
1925.			
Feb. 27	Verne W. Stambaugh	1.74	192
May 5	do	1.18	7.7
July 13	Stambaugh and Johnson	1.81	122
July 24	do	4.60	14,100
Aug. 6	do	3.27	4,330
Nov. 3	Verne W. Stambaugh	1.34	137
1926.			
Apr. 30	Verne W. Stambaugh	1.31	59.0
June 19	do	2.48	1,240
July 13	do	2.42	962
Aug. 2	J. B. Spiegel	.93	6.7

DAILY GAGE HEIGHT, in feet, and DISCHARGE, in second-feet, of Arkansas river at Syracuse, Kan., 1924-'25.

DAY.	October.		November.		December.		January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1924-'25.												
1	1.19	17	1.34	50	1.78	210	.....	.....	2.36	280	1.72	177
2	1.23	23	1.17	20	1.72	181	1.96	280	2.37	290	1.67	155
3	1.28	31	1.30	42	1.69	168	*	*	2.38	285	1.62	135
4	1.30	34	1.34	52	1.36	56	*	*	2.35	270	1.62	132
5	1.30	34	1.41	68	1.48	88	*	*	2.32	250	1.62	132
6	1.30	34	1.40	66	1.54	107	*	*	2.30	250	1.62	132
7	1.33	42	1.38	61	1.72	172	*	*	2.27	250	1.62	128
8	1.48	76	1.38	61	1.75	186	*	*	2.22	230	1.61	124
9	1.41	59	1.40	66	1.78	200	*	*	2.18	220	1.59	117
10	1.37	50	1.43	76	1.92	273	*	*	2.13	215	1.59	114
11	1.35	46	1.39	66	1.84	225	*	*	2.08	200	1.59	114
12	1.39	54	1.28	42	1.92	273	*	*	2.05	195	1.59	114
13	1.35	46	1.17	23	2.06	397	*	*	2.02	190	1.58	107
14	1.35	46	1.16	21	2.06	397	*	*	2.02	200	1.57	104
15	1.34	44	1.14	18	2.09	409	*	*	2.02	200	1.55	94
16	1.33	44	1.14	18	2.03	340	*	*	2.01	215	1.49	76
17	1.32	42	1.18	24	1.98	292	*	*	1.98	210	1.46	68
18	1.32	42	1.27	40	1.98	292	*	*	1.95	205	1.46	68
19	1.32	42	1.28	42	.....	.....	*	*	1.93	205	1.46	68
20	1.34	46	1.44	78	1.95	270	*	*	1.86	190	1.46	68
21	1.36	52	1.46	84	*	*	*	*	1.80	165	1.46	68
22	1.37	54	1.47	88	*	*	*	*	1.77	160	1.47	71
23	1.38	56	1.47	88	*	*	*	*	1.83	195	1.43	61
24	1.36	52	1.43	76	*	*	*	*	1.84	210	1.30	34
25	1.39	59	1.46	84	*	*	*	*	1.79	195	1.27	29
26	1.41	64	1.54	110	*	*	*	*	1.74	180	1.24	24
27	1.41	64	1.55	114	1.96	280	*	*	1.74	190	1.24	24
28	1.42	68	1.62	139	.....	.....	*	*	1.74	190	1.23	23
29	1.41	66	1.83	235	.....	.....	*	*	.....	.....	1.22	21
30	1.41	66	1.86	253	.....	.....	*	*	.....	.....	1.24	24
31	1.36	54	.....	.....	.....	.....	*	*	.....	.....	1.24	24

DAY.	April.		May.		June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1925.												
1	1.28	31	1.19	7	1.13	7	1.18	16	.....	4,400	.94	24
2	1.26	28	1.18	7	1.13	7	1.17	15	.....	2,000	.92	21
3	1.26	26	1.18	7	1.12	7	1.17	15	.....	1,410	.91	20
4	1.25	24	1.18	8	1.12	7	1.30	34	.....	905	.91	20
5	1.22	18	1.18	8	1.12	7	2.80	2,140	.....	735	.90	18
6	1.22	18	1.18	8	1.11	7	2.58	1,510	3.32	4,530	.90	18
7	1.23	18	1.22	14	1.79	177	2.18	653	3.36	4,600	.89	17
8	1.26	23	1.30	24	2.39	854	1.90	260	3.00	3,230	.89	17
9	1.25	20	1.27	20	2.48	1,020	1.76	168	2.60	2,030	.88	16
10	1.23	17	1.75	142	2.04	340	1.69	124	2.32	1,340	.87	15
11	1.22	15	1.99	260	1.83	200	1.61	84	2.09	888	.97	29
12	1.22	15	1.92	220	1.77	172	1.62	76	1.88	555	.98	32
13	1.21	13	2.04	292	1.69	139	1.77	110	1.78	397	1.05	46
14	1.21	13	1.79	159	1.55	94	1.66	76	1.80	420	1.17	73
15	1.21	10	1.66	110	1.41	56	1.49	38	2.14	983	1.33	124
16	1.20	9	1.53	71	1.37	48	1.46	32	1.84	480	1.55	220
17	1.21	10	1.46	56	1.32	38	1.47	34	1.69	299	1.66	286
18	1.20	9	1.42	48	1.34	42	1.45	31	1.55	215	1.58	235
19	1.19	8	1.39	42	1.36	46	1.43	28	1.44	164	1.42	159
20	1.19	8	1.30	26	1.34	42	1.45	31	1.36	132	1.36	135
21	1.17	6	1.19	11	1.32	38	.....	3,540	1.31	114	1.30	114
22	1.23	10	1.16	8	1.52	84	.....	7,140	1.24	91	1.30	114
23	1.20	7	1.14	7	1.47	71	.....	6,220	1.22	84	1.29	110
24	1.19	7	1.16	9	1.39	52	3.63	5,850	1.27	100	1.29	110
25	1.20	7	1.19	13	1.33	40	3.40	4,800	1.23	88	1.29	110
26	1.19	7	1.15	8	1.27	29	3.03	3,270	1.20	78	1.26	100
27	1.19	7	1.13	7	1.24	24	2.88	2,780	1.16	68	1.24	94
28	1.20	7	1.12	7	1.21	20	3.40	4,800	1.11	56	1.24	94
29	1.19	7	1.12	7	1.20	18	3.50	5,250	1.07	48	1.22	84
30	1.19	7	1.11	7	1.19	17	3.53	5,600	1.03	40	1.20	78
31	.....	.....	1.13	7	.....	.....	3.71	6,200	.97	29	.....	.....

* Ice conditions.

DAILY GAGE HEIGHT, in feet, and DISCHARGE, in second-feet, of Arkansas river at Syracuse, Kan., 1925-'26.

DAY.	October.		November.		December.		January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1925-'26.												
1	1.19	76	1.44	177	1.62	253	1.74	305	1.70	253	1.31	114
2	1.18	73	1.40	159	1.60	235	1.75	317	1.69	247	1.30	110
3	1.18	73	1.34	135	1.60	235	1.74	305	1.68	247	1.29	107
4	1.17	71	1.31	124	1.59	230	1.78	351	1.66	235	1.27	100
5	1.17	71	1.28	114	1.61	240	1.80	363	1.65	230	1.26	97
6	1.16	68	1.26	107	1.70	299	1.82	386	1.65	235	1.25	94
7	1.15	68	1.39	150	1.64	260	1.81	374	1.65	235	1.23	88
8	1.15	68	.....	175	1.66	273	1.80	363	.....	230	1.23	88
9	1.15	68	.....	175	1.60	235	1.78	340	.....	230	1.21	81
10	1.15	68	.....	175	1.58	225	1.74	299	.....	230	1.19	76
11	1.15	68	.....	175	1.57	215	1.80	363	.....	230	1.17	71
12	1.14	66	.....	175	1.54	200	1.80	363	.....	230	1.17	71
13	1.14	66	.....	175	1.53	195	1.79	340	1.60	220	1.15	66
14	1.15	68	1.80	450	1.49	177	1.79	340	1.62	230	1.13	61
15	1.16	71	1.77	397	1.46	164	1.77	317	1.61	230	1.13	61
16	1.17	73	1.77	397	1.42	146	1.73		1.58	215	1.11	56
17	1.18	76	1.73	351	1.41	142	1.71		1.58	215	1.09	52
18	1.18	78	1.73	351	1.52	190	1.72		1.54	200	1.07	48
19	1.20	84	1.73	351	1.59	220	1.73		1.53	195	1.03	40
20	1.25	100	1.70	317	1.62	235	1.74	280	1.57	215	1.01	36
21	1.30	117	1.70	317	1.63	240	1.74		1.55	210	1.02	38
22	1.31	121	1.71	328	1.62	235	1.74		1.50	186	1.06	46
23	1.31	121	1.73	351	1.60	225	1.75		1.45	164	1.08	50
24	1.27	107	1.74	351	1.57	210	1.69		1.41	146	1.09	52
25	1.26	104	1.73	340	1.65	253	1.64	225	1.38	139	1.09	52
26	1.24	97	1.73	340	1.71	292	1.62	215	1.37	135	1.08	50
27	1.23	94	1.70	305	1.73	305	1.61	210	1.35	128	1.08	50
28	1.24	97	1.68	292	1.73	299	1.63	220	1.34	124	1.08	50
29	1.33	132	1.67	286	1.74	305	1.67	235	.....	.....	1.08	50
30	1.44	177	1.64	266	1.74	305	1.69	247	.....	.....	1.07	48
31	1.45	181	.....	.....	1.74	305	1.74	279	.....	.....	1.09	52

DAY.	April.		May.		June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1926.												
1	1.13	61	1.31	61	1.18	31	1.59	124	.97	9	.77	3
2	1.18	71	1.30	61	1.16	28	1.52	97	.94	7	.77	3
3	1.24	88	1.28	59	1.15	26	1.47	81	.91	6	1.44	107
4	1.28	97	1.23	50	1.12	21	1.43	71	.87	5	1.46	114
5	1.31	107	1.19	42	1.10	18	1.39	59	.85	5	1.30	66
6	1.31	104	1.16	38	1.10	17	1.34	48	.82	5	1.24	52
7	1.31	100	1.16	40	1.09	16	1.30	40	.80	4	1.26	56
8	1.30	97	1.16	42	1.08	15	1.26	31	.79	4	1.16	36
9	1.29	91	1.23	59	1.07	14	1.30	38	.79	4	.97	9
10	1.29	88	1.32	84	1.53	124	1.58	110	.78	3	.92	6
11	1.32	97	1.33	91	1.71	215	1.65	132	.78	3	.90	6
12	1.34	100	1.33	94	1.82	247	1.80	195	.77	3	.88	6
13	1.35	104	1.35	100	1.77	220	2.40	925	.76	2	.87	5
14	1.35	100	1.38	114	1.83	253	2.18	555	.76	2	.87	5
15	1.37	104	1.45	142	2.02	435	2.07	409	.76	2	.86	5
16	1.37	104	1.59	210	2.01	420	1.88	247	.76	2	.86	5
17	1.37	100	1.65	235	1.78	225	1.69	155	.76	2	.84	5
18	1.38	100	1.85	409	1.97	374	1.54	104	.77	3	.82	5
19	1.38	100	1.82	363	2.52	1,320	1.45	78	.77	3	.81	5
20	1.37	94	1.71	260	2.39	1,040	1.38	64	.77	3	.81	5
21	1.37	91	1.63	210	2.18	669	1.31	48	.76	2	.81	5
22	1.37	91	1.54	168	1.87	273	1.27	42	.88	6	.81	5
23	1.37	88	1.48	139	1.75	200	1.24	38	1.45	110	.81	5
24	1.35	78	1.41	110	1.65	155	1.20	32	1.30	66	.80	4
25	1.33	71	1.36	88	1.58	128	1.19	31	1.23	50	.79	4
26	1.34	73	1.27	61	1.53	107	1.14	24	1.10	26	.....	.....
27	1.35	73	1.22	46	1.60	132	1.10	20	.98	10	.....	.....
28	1.34	68	1.20	40	1.90	279	1.07	17	.87	5	.....	.....
29	1.32	64	1.20	36	1.82	225	1.02	11	.82	5	.....	.....
30	1.31	59	1.20	34	1.68	159	1.00	10	.80	4	.....	.....
31	.....	.....	1.19	32	.....	.....	.98	9	.79	4	.....	.....

MONTHLY DISCHARGE of Arkansas river at Syracuse, 1924 to 1926.

MONTH.	Discharge in second-feet.			Run-off total in acre-feet.
	Maximum.	Minimum.	Mean.	
1924-'25.				
October	76	17	48.6	2,990
November	253	18	73.5	4,370
December	.....	.....	.....	15,000
January	.....	.....	.....	15,000
February	290	160	216	11,900
March	177	21	84.8	5,210
April	31	6	13.5	803
May	292	7	52.3	3,220
June	1,020	7	123	7,320
July	7,140	15	1,960	121,000
August	4,600	29	98.4	60,500
September	286	15	84.4	5,020
The year	7,140	6	349	252,000
1925-'26.				
October	181	66	90.3	5,550
November	450	107	260	15,500
December	305	142	237	14,600
January	386	210	299	18,400
February	253	124	207	11,600
March	114	36	66.3	4,080
April	107	59	88.8	5,280
May	409	32	113	6,950
June	1,320	14	246	14,600
July	555	9	124	7,620
August	110	2	11.8	726
September	114	3	21.1	1,260
The year	1,320	2	146	106,000

ARKANSAS RIVER AT GARDEN CITY.

Location. At highway bridge half a mile south of Garden City, in section 19, township 24 south, range 32 west.

Drainage area. Approximately 28,000 square miles.

Records available. June 20, 1922, to September 30, 1926.

Gage. Stevens automatic graphic water-stage register on downstream side of bridge pier, and staff gage on outside of gage well.

Discharge measurements. Made from bridge during high water and by wading at low stages.

Channel. Shifting.

Extremes of discharge. Maximum stage recorded, 7.86 feet, June 18, 1923 (discharge, 19,500 second-feet); maximum during the biennium, 6.60 feet, July 24, 1925 (discharge 11,600 second-feet); minimum discharge, 0. Gage heights with zero discharge indicate ground-water levels.

Ice. Stage-discharge relation affected by ice for short periods during extreme cold weather.

Diversions. Between the Syracuse station and this station five irrigation canals diverted water to the extent shown elsewhere in this report.

Accuracy. Rating curves well defined between stages of 2.59 and 7.03 feet. Daily discharge ascertained by applying mean daily gage heights to rating curve. Records fair.

DISCHARGE MEASUREMENTS of Arkansas river at Garden City, 1924-'26.

DATE.	Made by—	Apparent gage height.	Corrected gage height.	Discharge.
1924.		Feet.	Feet.	Sec.-ft.
Oct. 15	Kinnison and Knapp	3.04	2.94	.9
Dec. 15	Verne W. Stambaugh	4.12	4.02	356
1925.				
Feb. 26	Verne W. Stambaugh	3.36	3.26	34.0
June 10	Earl G. Johnson	3.50	3.40	40.2
July 23	Stambaugh and Johnson	5.03	4.91	2,170
July 25	do	5.39	5.27	4,720
1926.				
Apr. 30	Verne W. Stambaugh	3.12	2.99	3.9
June 21	do	3.31	3.18	18.7

DAILY GAGE HEIGHT, in feet, and DISCHARGE, in second-feet, of Arkansas river at Garden City, Kan., 1924-'25

DAY.	October.		November.		December.		January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1924-'25.												
1	3.02	3.0	3.08	8.0	3.48	69	.....	.....	3.67	164	3.44	71
2	3.02	3.0	3.10	9.0	3.50	74	.....	.....	3.67	164	3.39	56
3	2.97	1.5	3.11	10	3.47	66	3.40	48	3.75	206	3.33	41
4	2.97	1.5	3.11	10	3.50	74	.....	.....	3.81	242	3.28	31
5	2.95	1.2	3.13	12	.....	.....	.....	.....	3.90	308	3.23	24
6	2.93	.9	3.13	12	.....	.....	.....	.....	3.92	324	3.21	20
7	2.91	.6	3.14	13	.....	.....	.....	.....	3.90	308	3.21	20
8	2.92	.7	3.14	13	.....	.....	.....	.....	3.96	360	3.18	17
9	2.91	.6	3.14	13	.....	.....	.....	.....	3.95	350	3.16	15
10	2.84	.2	3.15	14	.....	.....	3.52	81	3.66	158	3.15	14
11	2.85	.2	3.15	14	.....	.....	.....	.....	3.54	107	3.16	15
12	2.86	.3	3.16	15	.....	.....	.....	.....	3.41	66	3.19	18
13	2.93	.9	3.16	15	.....	.....	.....	.....	3.36	53	3.25	25
14	2.95	1.2	3.16	15	.....	.....	.....	.....	3.35	51	3.24	24
15	2.95	1.2	3.16	15	4.03	370	.....	.....	3.33	46	3.26	26
16	2.97	1.5	3.17	16	3.90	260	.....	.....	3.30	41	3.23	23
17	2.98	1.7	3.17	16	.....	.....	.....	.....	3.30	41	3.20	19
18	2.97	1.5	3.17	16	.....	.....	.....	.....	3.40	64	3.18	17
19	2.92	.7	3.17	16	.....	.....	.....	.....	3.37	56	3.16	15
20	2.90	.4	3.19	18	.....	.....	.....	.....	3.35	51	3.12	11
21	3.07	7.0	3.21	20	.....	.....	.....	.....	3.32	45	3.08	8.0
22	3.07	7.0	3.22	21	.....	.....	.....	.....	3.45	77	3.07	7.0
23	3.07	7.0	3.24	24	.....	.....	.....	.....	3.41	66	3.07	7.0
24	3.07	7.0	3.25	25	.....	.....	3.52	100	3.34	48	3.07	7.0
25	3.07	7.0	3.23	23	.....	.....	3.60	132	3.29	40	3.06	6.0
26	3.08	8.0	3.24	24	3.28	29	3.60	132	3.28	38	3.07	7.0
27	3.07	7.0	3.23	23	.....	.....	3.59	128	3.46	81	3.07	7.0
28	3.07	7.0	3.26	26	.....	.....	3.58	123	3.56	115	3.08	8.0
29	3.07	7.0	3.30	31	.....	.....	3.57	119	.....	.....	3.08	8.0
30	3.08	8.0	3.35	40	.....	.....	3.57	119	.....	.....	3.09	8.0
31	3.08	8.0	.....	.....	.....	.....	3.61	136	.....	.....	3.11	10

DAY.	April.		May.		June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1925.												
1	3.34	38	3.08	5.0	2.76	0	2.22	0	4.80	2850	2.27	0
2	3.35	40	2.99	1.2	2.72	0	2.18	0	4.42	1820	2.23	0
3	3.28	29	2.97	1.0	2.63	0	2.16	0	3.88	832	2.21	0
4	3.24	24	2.94	.6	2.57	0	2.14	0	3.53	390	2.19	0
5	3.18	17	2.95	.9	2.51	0	2.12	0	3.32	206	2.18	0
6	3.13	12	2.98	1.4	2.46	0	.....	31	3.20	120	2.19	0
7	3.07	7.0	3.01	2.0	2.56	0	.....	24	4.54	2100	2.22	0
8	3.38	45	3.18	17	2.42	0	.....	18	4.80	2850	2.15	0
9	3.42	53	3.21	20	3.36	41	.....	12	4.52	2050	2.13	0
10	3.32	34	3.21	20	3.51	77	.....	8.0	4.13	1240	2.16	0
11	3.27	27	3.19	18	3.19	18	.....	5.0	3.91	875	2.41	0
12	3.22	21	3.22	21	3.09	8.0	2.64	3.0	3.59	450	2.47	1.0
13	3.19	17	3.29	30	2.85	.3	2.64	2.0	3.17	102	2.39	0
14	3.15	12	3.20	19	2.79	0	2.40	0	2.98	27	2.43	0
15	3.11	8.0	3.51	77	2.76	0	2.30	0	2.90	14	2.57	4.0
16	3.08	5.0	3.30	31	3.72	0	2.21	0	2.88	12	2.63	7.0
17	3.07	3.0	3.24	24	2.67	0	2.15	0	2.89	13	2.52	1.0
18	3.06	2.0	3.21	20	2.66	0	2.09	0	2.76	3.0	2.55	2.0
19	3.04	1.5	3.18	17	2.66	0	2.06	0	2.69	1.0	2.64	5.0
20	2.94	.3	3.13	12	2.58	0	2.06	0	2.68	1.0	2.59	3.0
21	2.94	.2	3.09	8.0	2.49	0	2.25	0	2.65	1.0	2.73	11
22	3.01	.9	3.05	6.0	2.42	0	5.33	3720	2.58	0	2.78	15
23	3.18	9.0	2.99	1.8	2.56	0	4.89	2130	2.52	0	2.75	11
24	3.08	3.0	2.93	.9	2.53	0	4.53	1110	2.47	0	2.74	9.0
25	3.03	1.4	2.90	.4	2.48	0	5.20	4400	2.45	0	2.71	6.0
26	3.02	1.4	2.86	.3	2.41	0	4.85	3020	2.41	0	2.71	5.0
27	3.04	1.7	2.88	.3	2.38	0	4.71	2560	2.39	0	2.70	4.0
28	3.17	11	2.88	.3	2.34	0	4.36	1690	2.36	0	2.66	2.0
29	3.18	12	2.81	.1	2.30	0	4.99	3560	2.34	0	2.54	0
30	3.18	13	2.76	0	2.25	0	4.78	2790	2.40	0	2.39	0
31	.....	.....	2.71	0	.....	.....	4.92	3280	2.31	0	.....	.....

DAILY GAGE HEIGHT, in feet, and DISCHARGE, in second-feet, of Arkansas river at Garden City, Kan., 1925-'26.

DAY.	October.		November.		December.		January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1925-'26.												
1	2.37	0	2.85	.2	3.13	12	.....	65	3.44	58	3.07	7.0
2	2.35	0	2.93	.9	3.14	13	.....	75	3.45	61	3.06	6.0
3	2.42	0	2.88	.3	3.15	14	3.53	84	3.34	38	3.06	6.0
4	2.40	0	2.87	.3	3.08	8.0	3.54	87	3.30	31	3.06	6.0
5	2.39	0	2.86	.3	3.07	7.0	3.53	84	3.28	29	3.06	6.0
6	2.38	0	2.94	1.0	3.16	15	3.56	94	3.26	26	3.05	6.0
7	2.39	0	3.13	12	3.18	17	3.54	87	3.25	25	3.04	5.0
8	2.40	0	3.04	5.0	3.25	25	3.53	84	3.24	24	3.04	5 0
9	2.38	0	3.17	16	3.27	27	3.53	84	3.22	21	3.05	6 0
10	2.38	0	3.18	17	3.22	21	3.53	84	3.21	20	3.18	17
11	2.50	0	3.30	31	3.25	25	3.53	84	3.19	18	3.14	13
12	2.55	0	3.60	107	3.22	21	3.52	81	3.19	18	3.09	8.0
13	2.64	0	3.61	111	3.19	18	3.50	74	3.20	19	3.04	5.0
14	2.74	0	3.46	64	3.12	11	3.50	74	3.23	23	3.08	8.0
15	2.75	0	3.39	46	3.09	8.0	3.55	91	3.19	18	3.06	6.0
16	2.75	0	3.38	45	3.10	9.0	3.57	97	3.20	19	3.05	6.0
17	2.70	0	3.34	38	3.13	12	3.59	104	3.19	18	3.04	5.0
18	2.85	.2	3.26	26	3.18	17	3.60	107	3.24	24	3.04	5.0
19	2.88	.3	3.20	19	3.31	33	3.70	148	3.41	51	3.02	3.0
20	2.89	.4	3.15	14	3.33	36	3.67	136	3.71	153	3.01	3.0
21	2.91	.6	3.12	11	3.32	34	3.67	136	3.61	111	3.10	9.0
22	2.92	.7	3.11	10	3.32	34	3.67	136	3.46	64	3.23	23
23	2.91	.6	3.14	13	3.33	36	3.67	136	3.37	43	3.19	18
24	2.90	.4	3.15	14	3.40	48	3.67	136	3.30	31	3.12	11
25	2.90	.4	3.14	13	3.35	40	3.67	136	3.23	23	3.09	8.0
26	2.89	.4	3.13	12	3.38	45	3.65	128	3.15	14	3.06	6.0
27	2.88	.3	3.11	10	3.38	45	3.61	111	3.12	11	3.06	6.0
28	2.83	.2	3.10	9.0	3.37	43	3.56	94	3.10	9.0	3.07	7.0
29	2.83	.2	3.14	13	3.37	43	3.57	97	.....	.....	3.07	7.0
30	2.81	.1	3.14	13	3.37	43	3.61	111	.....	.....	3.06	6.0
31	2.80	.1	.....	.....	3.37	43	3.54	87	.....	.....	3.08	8.0

DAY.	April.		May.		June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1926.												
1	3.15	14	2.99	4.0	2.76	0	2.29	0	2.02	0	1.68	0
2	3.14	13	2.99	4.0	2.68	0	2.24	0	1.97	0	1.67	0
3	3.13	12	2.93	1.5	2.66	0	2.23	0	1.92	0	1.66	0
4	3.16	15	2.90	1.0	2.69	0	2.31	0	1.89	0	1.87	0
5	3.22	21	2.88	.7	2.63	0	2.38	0	1.88	0	1.82	0
6	3.22	21	2.87	.6	2.60	0	2.47	0	1.87	0	1.76	0
7	3.22	21	2.89	.9	2.58	0	2.53	0	1.86	0	1.75	0
8	3.19	18	2.94	1.7	2.71	0	2.61	0	1.84	0	1.74	0
9	3.20	19	2.98	3.0	2.73	0	2.67	0	1.82	0	1.73	0
10	3.22	21	2.98	3.0	2.74	0	2.72	0	1.79	0	1.72	0
11	.....		2.99	4.0	2.65	0	2.72	0	1.75	0	1.71	0
12	.....		3.06	9.0	2.63	0	2.72	0	1.76	0	1.70	0
13	.....	15	3.05	8.0	2.59	0	2.72	0	1.77	0	1.69	0
14	.....		3.04	8.0	2.68	0	2.72	0	1.76	0	1.68	0
15	.....		3.00	5.0	2.76	0	2.73	0	1.76	0	1.68	0
16	3.10	9.0	2.97	3.0	2.71	0	2.70	0	1.74	0	1.66	0
17	3.08	8.0	2.97	3.0	2.67	0	2.76	0	1.74	0	1.66	0
18	3.05	6.0	2.97	3.0	3.07	7.0	2.54	0	1.74	0	1.65	0
19	3.03	4.0	2.97	3.0	3.14	13	2.46	0	1.73	0	1.65	0
20	3.02	3.0	3.09	12	3.15	14	2.45	0	1.73	0	1.64	0
21	3.05	6.0	3.07	10	3.15	14	2.36	0	1.74	0	1.64	0
22	3.19	18	2.92	1.4	3.02	3.0	2.26	0	1.76	0	1.64	0
23	3.20	19	2.81	0	2.91	.6	2.19	0	1.94	0	1.63	0
24	3.15	14	2.74	0	2.80	0	2.15	0	1.86	0	1.62	0
25	3.12	11	2.69	0	2.72	0	2.12	0	1.79	0	1.61	0
26	3.10	9.0	2.65	0	2.62	0	2.09	0	1.76	0	1.61	0
27	3.05	6.0	2.68	0	2.56	0	2.08	0	1.74	0	1.61	0
28	3.01	4.0	2.85	0	2.48	0	2.04	0	1.72	0	1.61	0
29	2.99	3.0	2.86	0	2.40	0	2.33	0	1.71	0	1.61	0
30	2.98	3.0	2.84	0	2.36	0	2.20	0	1.71	0	1.59	0
31	.....	.....	2.83	0	.....	.....	2.09	0	1.70	0	.....	.....

MONTHLY DISCHARGE of Arkansas river at Garden City, 1924 to 1926.

MONTH.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
1924-'25.				
October	8	.2	3.32	204
November	40	8	17.6	1,050
December	.....	.....	.....	7,306
January	.....	.....	.....	6,400
February	360	38	131	7,280
March	71	6	18.9	1,160
April	53	.2	15.0	893
May	77	0	11.5	707
June	77	0	4.81	286
July	4,400	0	915	56,300
August	2,850	0	515	31,700
September	15	0	2.87	171
The year	4,400	0	15.7	113,000
1925-'26.				
October	.7	0	.16	9.7
November	111	.2	22.4	1,330
December	48	7	25.9	1,590
January	148	65	101	6,210
February	153	9	35.7	1,980
March	23	3	7.78	478
April	21	3	11.9	739
May	12	0	2.90	178
June	14	0	1.72	102
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
The year	153	0	17.4	15,600

ARKANSAS RIVER AT LARNED.

Location. At highway bridge half a mile south of Larned in section 5, township 22 south, range 16 west.

Drainage area. Approximately 30,000 square miles.

Records available. June 20, 1922, to September 30, 1926.

Gage. Stevens automatic graphic water-stage register on downstream side of bridge pier, and staff gage on outside of gage well.

Discharge measurements. Made from bridge during high water and by wading at low stages.

Channel. Shifting.

Extremes of discharge. Maximum stage recorded, 9.50 feet, August 24, 1923 (discharge, 14,300 second-feet); maximum during biennium, 6.56 feet, July 26, 1925 (discharge, 3,920 second-feet); minimum stage, 0. Gage heights with zero discharge indicate ground-water levels.

Ice. Stage-discharge relation affected for short periods during extreme cold weather.

Accuracy. Rating curves fairly well defined. Daily discharge ascertained by applying mean daily gage heights to rating curve. Records fair.

DISCHARGE MEASUREMENTS of Arkansas river at Larned, 1924-'26.

DATE.	Made by—	Gage height.	Discharge.
1925.		Feet.	Sec.-ft.
Mar. 5	Verne W. Stambaugh	3.95	78.3
Mar. 11	J. H. Hofmann	3.81	36.5
Apr. 27	Verne W. Stambaugh	3.87	56.7
July 27	Earl G. Johnson	5.84	* 2,370
Aug. 12	Verne W. Stambaugh	5.02	1,230
Aug. 20	Earl G. Johnson	3.82	80.5
Oct. 15	Verne W. Stambaugh	3.43	19.6
1926.			
Apr. 20	Verne W. Stambaugh	3.78	114
May 3	do	3.64	61.3

DAILY GAGE HEIGHT, in feet, and DISCHARGE, in second-feet, of Arkansas river at Larned, Kan.. 1924-'25.

DAY.	October.		November.		December.		January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1924-'25.												
1	.....	0	1.18	0	1.16	0	1.31	0	1.31	0	3.92	65
2	.....	0	1.19	0	1.13	0	1.31	0	1.32	0	3.89	56
3	.....	0	1.17	0	1.20	0	1.30	0	1.32	0	3.94	73
4	.....	0	1.16	0	1.21	0	1.30	0	2.82	160	3.91	62
5	.....	0	1.15	0	1.22	0	1.30	0	4.39	371	3.95	76
6	.....	0	1.14	0	1.21	0	1.30	0	4.34	326	3.94	73
7	.....	0	1.12	0	1.23	0	1.30	0	4.33	317	3.89	56
8	.....	0	1.12	0	1.21	0	1.30	0	4.28	274	3.86	48
9	.....	0	1.13	0	1.21	0	1.30	0	4.27	266	3.85	46
10	.....	0	1.11	0	1.21	0	1.31	0	4.30	290	3.80	34
11	.....	0	1.11	0	1.20	0	1.30	0	4.34	326	3.79	32
12	.....	0	1.11	0	1.19	0	1.30	0	4.40	380	3.81	36
13	.....	0	1.12	0	1.20	0	1.29	0	4.40	380	3.89	56
14	1.33	0	1.12	0	1.21	0	1.29	0	4.35	335	3.80	34
15	1.28	0	1.11	0	1.26	0	1.29	0	4.28	274	3.85	46
16	1.22	0	1.10	0	1.28	0	1.29	0	4.21	218	3.83	41
17	1.17	0	1.10	0	1.30	0	1.29	0	4.13	164	3.83	41
18	1.19	0	1.10	0	1.30	0	1.29	0	4.07	130	3.85	46
19	1.19	0	1.11	0	1.30	0	1.29	0	4.09	140	3.83	41
20	1.21	0	1.13	0	1.30	0	1.29	0	4.05	120	3.83	41
21	1.21	0	1.12	0	1.30	0	1.29	0	4.00	95	3.80	34
22	1.21	0	1.12	0	1.31	0	1.29	0	3.97	84	3.77	29
23	1.21	0	1.13	0	1.31	0	1.29	0	3.96	80	3.75	26
24	1.21	0	1.13	0	1.30	0	1.29	0	3.96	80	3.71	20
25	1.23	0	1.13	0	1.30	0	1.30	0	3.94	73	3.69	17
26	1.22	0	1.13	0	1.31	0	1.30	0	3.96	80	3.64	11
27	1.23	0	1.13	0	1.31	0	1.30	0	3.98	88	3.61	8
28	1.21	0	1.15	0	1.31	0	1.30	0	3.95	76	3.60	7
29	1.21	0	1.16	0	1.31	0	1.30	0	.....	.....	3.59	6
30	1.21	0	1.16	0	1.31	0	1.30	0	.....	.....	3.59	6
31	1.20	0	.....	.....	1.31	0	1.30	0	.....	.....	3.62	8

DAY.	April.		May.		June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1925.												
1	3.78	31	3.94	73	3.43	1	1.97	0	5.45	1800	3.58	33
2	3.82	39	3.92	65	3.33	0	1.82	0	5.93	2540	3.52	28
3	3.87	51	3.89	56	3.28	0	1.77	0	5.65	2080	3.43	21
4	3.90	58	3.84	44	3.07	0	1.73	0	5.41	1740	3.34	15
5	3.92	65	3.81	36	2.95	0	1.70	0	4.97	1160	3.25	10
6	3.86	48	3.80	34	2.83	0	1.85	0	4.76	912	3.18	7
7	3.82	39	3.77	29	2.71	0	2.13	0	4.50	630	3.10	4
8	3.76	28	3.79	32	2.59	0	1.89	0	4.36	504	3.02	0
9	3.75	26	3.86	48	2.64	0	1.78	0	4.38	522	2.93	0
10	3.74	24	3.87	51	2.62	0	1.73	0	5.38	1700	3.27	12
11	3.70	18	3.83	41	2.45	0	1.75	0	5.21	1480	3.18	7
12	3.70	18	3.84	44	2.81	0	1.72	0	5.04	1250	3.15	6
13	3.68	16	3.82	39	3.11	0	1.69	0	4.90	1080	3.17	7
14	3.67	15	3.79	32	3.30	0	1.67	0	4.63	763	3.60	35
15	3.65	12	4.14	171	3.31	0	1.63	0	4.39	531	3.66	44
16	3.63	10	4.13	164	3.00	0	1.59	0	4.26	414	3.63	40
17	3.63	10	4.28	274	2.81	0	1.54	0	4.14	306	3.57	34
18	3.63	10	4.28	274	2.68	0	1.50	0	4.03	214	3.43	21
19	3.60	7	4.15	178	2.58	0	1.42	0	3.92	138	3.30	13
20	3.59	6	4.12	158	2.49	0	1.78	0	3.82	85	3.18	7
21	3.59	6	4.03	110	2.42	0	2.62	0	3.78	66	3.23	10
22	3.60	7	3.93	69	2.35	0	2.37	0	3.73	56	3.45	22
23	3.68	16	3.83	41	2.31	0	2.28	0	3.68	47	3.67	36
24	3.58	6	3.74	34	2.25	0	2.24	0	3.67	46	4.12	288
25	3.57	6	3.69	17	2.19	0	4.82	1370	3.53	29	3.97	170
26	3.80	34	3.65	12	2.12	0	5.94	2560	3.44	22	3.80	75
27	3.87	51	3.59	6	2.06	0	5.85	2400	3.32	14	3.72	54
28	3.98	88	3.61	8	2.01	0	5.46	1810	3.26	11	3.62	38
29	4.01	100	3.59	6	1.96	0	5.12	1360	3.23	10	3.49	25
30	3.96	80	3.51	2	1.91	0	4.89	1070	3.81	80	3.46	23
31	.....	.....	3.46	2	.....	.....	5.57	1970	3.65	42	.....	.....

DAILY GAGE HEIGHT, in feet, and DISCHARGE, in second-feet, of Arkansas river at Larned, Kan., 1925-'26.

DAY.	October.		November.		December.		January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1925-'26.												
1	3.45	23	3.42	20	3.65	43	.....	45	4.25	405	3.79	121
2	3.44	22	3.49	25	3.66	44	.....	50	4.08	282	3.77	113
3	3.43	21	3.48	25	3.63	40	.....	65	3.99	224	3.76	109
4	3.42	20	3.44	22	3.57	32	.....	90	3.93	192	3.76	109
5	3.41	20	3.37	17	3.61	37	3.82	85	3.86	155	.....	106
6	3.39	18	3.41	20	3.56	31	3.90	125	3.90	175	3.74	102
7	3.38	18	3.71	53	3.64	41	.....	150	3.87	160	3.72	94
8	3.37	17	3.83	90	3.62	38	.....	140	3.83	140	3.73	98
9	.....	17	3.84	95	3.63	40	.....	140	3.76	109	3.73	98
10	3.37	17	3.78	70	3.65	43	.....	140	3.73	98	3.73	98
11	3.37	17	3.75	63	3.65	43	.....	160	3.69	83	3.74	102
12	3.32	14	3.74	60	3.65	43	.....	180	3.68	80	3.77	113
13	3.30	13	3.77	68	3.67	46	.....	220	3.65	70	3.76	109
14	3.38	18	3.81	80	3.60	35	4.13	297	3.62	60	3.73	98
15	3.42	20	3.86	105	3.52	28	4.02	206	3.62	60	3.71	90
16	3.41	20	4.06	238	.....	24	4.14	306	3.64	66	3.70	86
17	3.44	22	4.06	238	.....	28	4.20	360	3.69	83	3.67	76
18	3.45	23	4.01	198	3.59	34	4.17	333	3.58	48	3.64	66
19	3.43	21	3.99	184	3.71	53	4.17	333	3.68	80	3.66	73
20	3.42	20	3.96	164	3.68	47	.....	270	3.74	102	3.60	53
21	3.41	20	3.90	125	.....	45	.....	260	3.87	160	3.67	76
22	3.42	20	3.81	80	.....	43	.....	250	3.95	202	3.74	102
23	3.33	15	3.80	75	.....	46	.....	240	3.99	224	3.68	80
24	3.41	20	3.77	68	.....	45	.....	230	4.14	323	3.66	73
25	3.49	25	3.75	63	3.70	50	.....	220	3.97	214	3.62	60
26	3.52	28	3.73	58	.....	44	.....	210	3.79	121	3.63	63
27	3.48	25	3.70	50	.....	42	.....	210	3.92	186	3.62	60
28	3.38	18	3.67	46	.....	42	.....	220	3.86	155	3.62	60
29	3.40	19	3.67	46	.....	42	.....	240	.....	.....	3.49	26
30	3.40	19	3.67	46	.....	42	4.26	414	.....	.....	3.41	12
31	3.38	18	.....	.....	.....	42	4.37	513	.....	.....	3.40	10

DAY.	April.		May.		June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1926.												
1	3.39	9	3.64	66	3.22	0	1.87	0	1.07	0	.97	0
2	3.39	9	3.64	66	3.20	0	1.81	0	1.08	0	.98	0
3	3.50	28	3.64	66	3.15	0	1.78	0	1.06	0	.98	0
4	4.06	269	3.61	56	3.28	0	1.75	0	1.03	0	1.32	0
5	4.03	250	3.61	56	3.26	0	1.71	0	1.01	0	1.16	0
6	3.95	202	3.63	63	3.15	0	1.69	0	1.00	0	1.09	0
7	3.91	180	3.74	102	3.10	0	1.65	0	.99	0	1.05	0
8	3.89	170	3.78	117	3.10	0	1.62	0	.99	0	1.04	0
9	3.86	155	3.77	113	3.09	0	1.58	0	.98	0	1.04	0
10	3.88	165	3.75	106	3.03	0	1.55	0	.99	0	1.03	0
11	3.97	214	3.71	90	2.94	0	1.51	0	1.00	0	1.05	0
12	3.99	224	3.72	94	2.71	0	1.48	0	1.00	0	1.10	0
13	3.96	208	3.70	86	2.62	0	1.44	0	.99	0	1.22	0
14	3.92	186	3.67	76	2.60	0	1.41	0	.99	0	1.52	0
15	3.90	175	3.67	76	2.59	0	1.38	0	.99	0	1.59	0
16	3.89	170	3.68	80	2.58	0	1.33	0	.98	0	1.74	0
17	3.85	150	3.64	66	2.58	0	1.33	0	.98	0	2.39	0
18	3.78	117	3.65	70	2.64	0	1.31	0	.97	0	3.42	18
19	3.79	121	3.62	60	3.03	0	1.28	0	.96	0	2.86	0
20	3.78	117	3.58	48	3.00	0	1.24	0	.96	0	2.49	0
21	3.76	109	3.55	40	2.56	0	1.21	0	.96	0	2.30	0
22	3.75	106	3.50	28	2.37	0	1.18	0	.96	0	2.15	0
23	3.74	102	3.46	21	2.22	0	1.16	0	.95	0	2.03	0
24	3.69	83	3.41	12	2.21	0	1.14	0	.95	0	.....	0
25	3.66	73	3.35	5	2.15	0	1.13	0	.95	0	.....	0
26	3.67	76	3.30	0	2.12	0	1.11	0	.95	0	.....	0
27	3.68	80	3.29	0	2.07	0	1.09	0	.96	0	.....	0
28	3.67	76	3.28	0	2.03	0	1.05	0	.98	0	.....	0
29	3.67	76	3.25	0	1.99	0	1.05	0	.98	0	.....	0
30	3.65	70	3.25	0	1.94	0	1.05	0	.98	0	1.78	0
31	.....	.....	3.25	0	.....	.....	1.06	0	.97	0	.....	.....

MONTHLY DISCHARGE of Arkansas river at Larned, 1924 to 1926.

MONTH.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
1924-'25.				
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0
January	0	0	0	0
February	380	0	183	10,200
March	76	6	37.9	2,330
April	100	6	30.8	1,830
May	274	2	69.4	4,260
June	1	0	.03	2
July	2,560	0	405	24,800
August	2,540	10	654	40,200
September	288	0	36.2	2,150
The year	2,560	0	119	85,800
1925-'26.				
October	28	13	19.6	1,210
November	238	17	83.1	4,940
December	53	17	40.4	2,480
January	513	45	215	13,200
February	405	48	152	8,440
March	121	10	81.8	5,030
April	269	9	132	7,860
May	117	0	53.6	3,300
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	18	0	.60	36
The year	513	0	64.3	46,500

PAWNEE RIVER AT LARNED.

Location. At Moffet dam 11½ miles west of Larned, in section 33, township 21 south, range 10 west.

Drainage area. Approximately 2,300 square miles.

Records available. November 21, 1924, to September 30, 1926. Prior to that date records obtained from April, 1924, at bridge east of State Hospital at Larned.

Gage. Automatic water-stage recorder attached to downstream side of right abutment of Moffet dam, and staff gage on outside of gage well.

Discharge measurements. Made by wading at low stages.

Channel. Nearly permanent.

Accuracy. Rating curve well defined for low stages, but not definite enough above a gage height of 4.50 feet to ascertain daily discharges.

DISCHARGE MEASUREMENTS of Pawnee river at Larned, 1924-'26.

DATE.	Made by—	Gage height.	Discharge.
		Feet.	Sec.-ft.
1924.			
Dec. 3	Verne W. Stambaugh	2.44	3.3
1925.			
Mar. 2	Verne W. Stambaugh	2.60	7.9
Apr. 28	do	2.70	13.7
June 15	Stambaugh and Knapp	4.12	163
June 18	Stambaugh and Johnson	2.99	39.8
July 10	Earl G. Johnson	2.39	2.7
July 28	do	5.60	324
Aug. 11	Verne W. Stambaugh	4.18	199
Aug. 12	do	4.88	253
Aug. 19	Earl G. Johnson	2.59	9.2
1926.			
June 23	Verne W. Stambaugh	2.34	2.1
July 31	J. B. Spiegel	2.39	2.6
Aug. 21	Verne W. Stambaugh	3.70	129
Aug. 21	do	4.35	197

DAILY GAGE HEIGHT, in feet, of Pawnee river near Larned, Kan., 1924-'25.

DAY.	October.		November.		December.		January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1924-'25.												
1			2.08								2.62	
2			1.87								2.60	
3			1.61		2.44		2.46				2.60	
4			1.46				2.53				2.61	
5			1.36				2.56				2.62	
6			1.31				2.75				2.60	
7			1.35				2.76				2.60	
8			1.45				2.77				2.60	
9			1.60				2.72				2.61	
10			1.74				2.68				2.60	
11			1.76				2.64				2.57	
12			1.77								2.58	
13			1.76								2.60	
14			1.76								2.55	
15	.91		1.73								2.57	
16	.90		1.65								2.59	
17	.89		1.62								2.60	
18	.88		1.62								2.60	
19	.88		1.62								2.59	
20	1.03										2.60	
21	2.13		2.53								2.59	
22	2.29		2.51								2.59	
23	2.26		2.49								2.60	
24	2.19		2.48						2.62		2.60	
25	2.05		2.47						2.61		2.58	
26	1.75		2.47						2.61		2.56	
27	1.48		2.46						2.62		2.50	
28	1.33		2.43						2.63		2.59	
29	1.25		2.37				2.75				2.63	
30	1.37		2.39								2.60	
31	2.12										2.60	

DAY.	April.		May.		June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1925.												
1	2.58		3.05				2.55		3.14		3.20	
2	2.65		2.90				2.57		3.63		3.06	
3	11.87		2.84				2.51		3.51		2.85	
4	15.99		2.82				2.44		3.31		2.71	
5	7.39		2.78				2.46		3.20		2.59	
6	3.47		2.72				2.44		3.13		2.59	
7	3.14		2.67				2.42		3.02		2.56	
8	3.04		2.68				2.40		2.99		2.46	
9	2.96		2.67				2.37		3.13		2.51	
10	2.91		2.66				2.39		3.12		2.57	
11	3.04		2.67				2.34		3.62		2.57	
12	2.96		2.67				2.34		4.41		2.58	
13	2.88		2.66				2.38		3.27		2.94	
14	2.87		2.66				2.36		3.18		2.78	
15	2.86		3.17		3.56		2.34		3.19		2.66	
16	2.83		4.05		3.25		2.94		3.02		2.60	
17	2.80		8.09		3.10		2.74		2.87		2.59	
18	2.78		10.46		3.00		2.58		2.75		2.59	
19	2.76		4.96		2.92		2.49		2.59		2.59	
20	2.74		3.18		2.96		2.59		2.55		2.55	
21	2.73		3.08		2.79		3.03		2.54		2.52	
22	2.70		3.02		2.72		2.75		2.48		2.50	
23	2.69		2.93		2.66		2.60		2.44		2.50	
24	2.68				2.61		2.54		2.40		2.48	
25	2.64				2.58		2.91		2.32		2.92	
26	2.64				2.58		2.91		2.32		2.94	
27	2.67				2.60		5.57		2.31		2.78	
28	2.76				2.59		7.33		2.31		2.68	
29	5.18				2.56		4.72		2.45		2.58	
30	3.57				2.54		3.58		2.53		2.51	
31							3.28		2.62			

DAILY GAGE HEIGHT, in feet, of Pawnee river near Larned, Kan., 1925-'26.

DAY.	October.		November.		December.		January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1925-'26.												
1	2.47	.....	2.32	.....	2.46	.....	2.31	.....	.64	.....	1.16	.....
2	2.46	.....	2.31	.....	2.50	.....	2.37	.....	.65	.....	1.11	.....
3	2.42	.....	2.35	.....	2.56	.....	2.46	.....	.66	.....	1.13	.....
4	2.38	.....	2.54	.....	2.47	.....	2.46	.....	.66	.....	1.09	.....
5	2.37	.....	2.74	.....	2.37	.....	2.45	.....	.66	.....	1.02	.....
6	2.35	.....	2.75	.....	2.40	.....	2.44	.....	.76	.....	1.11	.....
7	2.38	.....	2.98	.....	2.43	.....	2.44	.....	.81	.....	.97	.....
8	2.36	.....	2.82	.....	2.45	.....	2.44	.....	.79	.....	.88	.....
9	2.36	.....	2.87	.....	2.45	.....	2.46	.....	.74	.....	.86	.....
10	2.36	.....	3.00	.....	2.45	.....	2.45	.....	.70	.....	.94	.....
11	2.36	.....	3.49	.....	2.47	.....	2.43	.....	.70	.....	.88	.....
12	2.33	.....	3.69	.....	2.52	.....	2.41	.....	.72	.....	.83	.....
13	2.30	.....	3.34	.....	2.54	.....	2.39	.....	.71	.....	.78	.....
14	2.31	.....	3.32	.....	2.56	.....	.58	.....	.65	.....	.79	.....
15	2.30	.....	3.34	.....	2.47	.....	.59	.....	.59	.....	.76	.....
16	2.39	.....	3.13	.....	2.46	.....	.60	.....	.59	.....	.75	.....
17	2.39	.....	2.95	.....	2.48	.....	.60	.....	.68	.....	.76	.....
18	2.38	.....	2.77	.....	2.50	.....	.60	.....	1.82	.....	.78	.....
19	2.38	.....	2.59	.....	2.50	.....	.63	.....	1.02	.....	.90	.....
20	2.36	.....	2.59	.....	2.38	.....	.60	.....	.77	.....	.90	.....
21	2.32	.....	2.64	.....	2.32	.....	.59	.....	1.05	.....	.96	.....
22	2.32	.....	2.63	.....	2.32	.....	.55	.....	1.13	.....	1.11	.....
23	2.26	.....	2.69	.....	2.38	.....	.55	.....	1.09	.....	.97	.....
24	2.33	.....	2.57	.....	2.37	.....	.53	.....	1.29	.....	.94	.....
25	2.27	.....	2.50	.....	2.40	.....	.53	.....	1.36	.....	.83	.....
26	2.29	.....	2.48	.....	2.42	.....	.54	.....	1.56	.....	.81	.....
27	2.34	.....	2.52	.....	2.42	.....	.54	.....	1.45	.....	.73	.....
28	2.39	.....	2.38	.....	2.32	.....	.55	.....	1.35	.....	.62	.....
29	2.61	.....	2.37	.....	2.32	.....	.57	.....	.....	.....	.74	.....
30	2.73	.....	2.44	.....	2.33	.....	.63	.....	.....	.....	.91	.....
31	2.50	.....	.....	.....	2.33	.....	.66	.....	.....	.....	.90	.....

DAY.	April.		May.		June.		July.		August.		September.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1926.												
1	.99	.....	.49	.....	2.55	.....	2.35	.....	2.41	.....	2.36	.....
2	.99	.....	.54	.....	2.55	.....	2.30	.....	2.41	.....	2.38	.....
3	.90	.....	.49	.....	2.55	.....	2.30	.....	2.42	.....	2.39	.....
4	.97	.....	.33	.....	2.49	.....	2.36	.....	2.42	.....	2.39	.....
5	1.37	.....	.23	.....	2.49	.....	2.42	.....	2.42	.....	2.39	.....
6	1.59	.....	.20	.....	2.52	.....	2.37	.....	2.43	.....	2.95	.....
7	1.62	.....	.21	.....	2.46	.....	2.33	.....	2.42	.....	3.44	.....
8	1.65	.....	.26	.....	2.40	.....	2.32	.....	2.43	.....	3.25	.....
9	1.66	.....	.67	.....	2.29	.....	2.31	.....	2.43	.....	3.20	.....
10	1.62	.....	.74	.....	2.35	.....	2.32	.....	2.43	.....	2.99	.....
11	1.67	.....	.77	.....	2.48	.....	2.27	.....	2.43	.....	2.80	.....
12	1.69	.....	1.94	.....	2.86	.....	2.27	.....	2.44	.....	2.73	.....
13	1.61	.....	3.03	.....	2.99	.....	2.27	.....	2.47	.....	6.28	.....
14	1.56	.....	2.94	.....	2.82	.....	2.16	.....	2.46	.....	4.43	.....
15	1.49	.....	2.84	.....	2.74	.....	2.29	.....	2.44	.....	3.00	.....
16	1.47	.....	2.80	.....	2.70	.....	2.37	.....	2.43	.....	8.08	.....
17	1.37	.....	2.78	.....	2.63	.....	2.54	.....	2.42	.....	4.60	.....
18	1.36	.....	2.75	.....	2.60	.....	2.71	.....	2.42	.....	2.91	.....
19	1.33	.....	2.67	.....	2.54	.....	2.56	.....	2.38	.....	2.72	.....
20	1.26	.....	2.66	.....	2.55	.....	2.43	.....	2.33	.....	2.61	.....
21	1.14	.....	2.63	.....	2.53	.....	2.43	.....	3.28	.....	2.51	.....
22	1.10	.....	2.60	.....	2.38	.....	2.43	.....	3.56	.....	2.47	.....
23	1.12	.....	2.60	.....	2.34	.....	2.38	.....	2.90	.....	2.52	.....
24	1.02	.....	2.60	.....	2.47	.....	2.34	.....	2.73	.....	2.50	.....
25	.90	.....	2.57	.....	2.45	.....	2.34	.....	2.50	.....	2.42	.....
26	.92	.....	2.56	.....	2.37	.....	2.34	.....	2.34	.....	2.36	.....
27	.91	.....	2.52	.....	2.43	.....	2.33	.....	2.31	.....	2.30	.....
28	.82	.....	2.47	.....	2.47	.....	2.34	.....	2.31	.....	.....	.....
29	.78	.....	2.47	.....	2.46	.....	2.36	.....	2.34	.....	.....	.....
30	.62	.....	2.45	.....	2.40	.....	2.37	.....	2.37	.....	.....	.....
31	.....	.....	2.50	.....	.....	.....	2.39	.....	2.34	.....	.....	.....

THE GARDEN CITY CANAL.

Location. In section 4, township 24 south, range 34 west, in Finney county, about one-half mile below head gate.

Records available. Irrigation seasons of 1920 to 1926. Water-stage recorder out of order March 1 to July 14, 1926; during this period the station was visited weekly by the observer, and whenever the canal was carrying water at such times, the gage height was noted by the observer.

Gage. Gurley automatic graphic water-stage recorder installed on south bank of canal about 40 feet downstream from wagon bridge prior to 1926. In February, the gage was moved a mile and a half farther downstream.

Discharge measurements. Made by wading.

Accuracy. Stage-discharge relation affected by shifting sand in bottom of canal. Banks permanent. Daily discharge ascertained by applying mean daily gage heights to rating curve.

DISCHARGE MEASUREMENTS of Garden City canal, 1924-'26.

DATE.	Made by—	Gage height.	Discharge.
1926.		Feet.	Sec.-ft.
Mar. 27	Verne W. Stambaugh	1.25	15.1
Apr. 17	do	1.18	16.3
May 1	do	1.11	15.2
June 19	do	1.85	57.5
July 17	do	.42	3.2

DAILY DISCHARGE, in second-feet, of Garden City canal near Garden City, Kan., 1924-'26.

DAY.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1924-'25.												
1						1	1				1	
2						1	1					
3						1						
4						1						
5												
6												
7												
8									14			
9							1	13	13			
10							1	9	2			
11							1	7			6	
12							1	6			15	
13							1	1			6	
14								1				
15								4				
16							1				12	
17							1				9	
18							1				7	
19												
20												
21												
22												
23												
24										1		
25										1		
26										1		
27										1		
28					1					1		
29										4		
30										1		
31										1		

DAY.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1925-'26.												
1		18					17	15				
2		7										
3										10		
4												10
5									7			10
6												2
7												
8												
9												
10										12		
11												
12									12			
13												
14												
15												
16												
17	13									3		
18	9											
19	6								56			
20	6											
21	6											
22	6											
23	6											
24	7											
25	7											
26	7								12			
27	6											
28	6											
29	11							3				
30	23											
31	24											

MONTHLY DISCHARGE of Garden City canal near Garden City, Kan., 1924 to 1926.

MONTH.	Discharge in second-feet.		Run-off (total in acre-feet.)
	Maximum.	Mean.	
1925.			
February 28	1	1.0	2
March 1-4	1	1.0	8
April 1-2, 9-13, 16-18	1	1.0	20
May 8-15	13	6.63	105
June 8-10	14	9.67	57
July 24-31	4	1.38	22
August 1, 11-13, 16-18	15	8.14	113
The period			327
1925-'26.			
October 17-31	24	9.53	283
November 1-2	18	12.5	50
September 4-6	10	7.33	44
The period			377

FARMERS' DITCH.

Location. In section 5, township 24 south, range 34 west, in Finney county, about three-fourths of a mile below head gate.

Records available. Irrigation seasons of 1920 to 1926.

Gage. Gurley automatic graphic water-stage recorder installed on north bank of canal at downstream end of wagon bridge.

Discharge measurements. Made from wagon bridge.

Accuracy. Stage-discharge relation shifting. Daily discharges ascertained by applying mean daily gage heights to rating curve. Records good.

DISCHARGE MEASUREMENTS of Farmers' ditch, 1924-'26.

DATE.	Made by—	Gage height.	Discharge.
1925.		Feet.	Sec.-ft.
June 12	Knapp and Johnson	.95	21.3
June 13	Knapp and Stambaugh	.57	6.6
July 25	Stambaugh and Johnson	2.16	104
Aug. 1	Earl G. Johnson	2.2	110
Aug. 8	do	2.60	152
Aug. 15	do	1.70	60.8
Oct. 17	Verne W. Stambaugh	.87	13.2
Oct. 31	do	1.04	22.8
1926.			
May 22	Verne W. Stambaugh	.76	18.9
June 12	do	2.38	129
June 19	do	2.63	161
June 26	do	2.43	136

DAILY DISCHARGE, in second-feet, of Farmers' ditch near Garden City, Kan., 1924 to 1926.

DAY.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1924-'25.												
1											112	
2						93					124	
3						83					123	
4						36					109	
5											125	
6										116	103	
7										56	155	
8									110	56	150	
9									182		132	
10									76		110	
11									61		59	14
12									18		126	28
13									6		77	14
14											42	48
15											61	107
16											113	116
17											98	121
18											85	120
19											38	72
20												90
21												104
22										127		101
23										136		97
24										146		101
25										106		79
26										121		29
27										133		
28										101		
29										104		
30										78		
31										110		

DAY.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1925-'26.												
1		27				30						
2		10				59						
3						66			10			
4						66						
5						70						
6						61						
7	19					59						
8	37					56						
9	43					53						
10	27					57						
11	19					53						
12	18					43			120			
13	17					37			150			
14	16					46			129	63		
15	15					43			126	40		
16	14					33			157	27		
17	13	8				22			155			
18	12	20							173			
19	12	26							158			
20	11	19						17	133			
21	10	19						34	152			
22	10							17	121			
23	10							11	155			
24	10							7	151			
25	10							5	133			
26	9							4	130			
27	8				15			15	64			
28	7				30			16	80			
29	9							7	36			
30	18							6				
31	27							4				

MONTHLY DISCHARGE of Farmers' ditch near Garden City, Kan., 1924 to 1926.

MONTH.	Discharge in second-feet.		Run-off (total in acre-feet).
	Maximum.	Mean.	
1925.			
March 2-4	93	70.7	420
June 8-13	182	75.5	897
July 6-8, 22-31	146	107	2,750
August 1-19	155	102	3,850
September 11-26	121	77.5	2,460
The period			10,400
1925-'26.			
October 7-31	43	16.0	794
November 1-2, 17-21	27	18.4	255
February 27-28	30	22.5	89
March 1-17	70	50.2	1,690
May 20-31	34	11.9	283
June 3, 12-29	173	123	4,620
July 14-16	63	43.3	257
The period			7,990

GREAT EASTERN CANAL.

Location. In section 15, township 25 south, range 37 west, south of Hartland, in Kearny county, and about one-half mile downstream from head gate.

Records available. Irrigation seasons of 1920 to 1926. No record was obtained during the period November 9 to 13 inclusive, 1925.

Gage. Gurley automatic water-stage recorder, installed on south bank of canal about 150 feet upstream from highway bridge across canal.

Discharge measurements. Made from highway bridge.

Accuracy. Stage-discharge relation affected somewhat by sand deposits in bed of canal. Daily discharge ascertained by applying mean daily gage heights to rating curves. Records fair.

Reservoir storage. In addition to the water diverted during the irrigation season, March to November, inclusive, about 20,000 acre-feet are, as a rule, diverted through this canal each winter for storage in Lake McKinney.

DISCHARGE MEASUREMENTS of Great Eastern canal, 1924-'26.

DATE.	Made by—	Gage height.	Discharge.
1924.		Feet.	Sec.-ft.
Nov. 29	Verne W. Stambaugh	1.93	100
1925.			
June 12	Knapp and Johnson	1.88	116
July 25	Stambaugh and Johnson	3.51	483
Aug. 1	Earl G. Johnson	3.41	403
Aug. 8	do	3.40	328
Aug. 15	do	3.69	385
Oct. 31	Verne W. Stambaugh	2.35	146
1926.			
May 15	Verne W. Stambaugh	2.15	102
May 22	do	2.91	233
May 29	do	1.38	35.8
July 10	do	1.05	15.9
July 17	do	2.40	161

DAILY DISCHARGE, in second-feet, of Great Eastern canal near Hartland, Kan., 1924 to 1926.

DAY.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1924-'25.												
1	.....	.....	216	.....	.....	121	.....	.....	.....	.....	367	.....
2	.....	.....	197	.....	.....	142	.....	.....	.....	.....	340	.....
3	.....	.....	176	.....	.....	33	.....	.....	.....	.....	288	.....
4	.....	.....	46	.....	.....	.....	.....	.....	.....	.....	243	.....
5	.....	.....	120	.....	.....	.....	.....	.....	.....	202	194	.....
6	.....	.....	99	.....	.....	.....	.....	.....	.....	446	231	.....
7	.....	.....	.....	.....	.....	.....	.....	.....	.....	275	338	.....
8	.....	.....	.....	.....	.....	.....	.....	.....	.....	184	326	.....
9	.....	.....	.....	.....	.....	.....	.....	.....	.....	130	246	.....
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	80	224	.....
11	.....	.....	.....	.....	.....	.....	.....	191	.....	47	191	.....
12	.....	.....	.....	.....	.....	.....	.....	100	118	.....	136	.....
13	.....	.....	.....	.....	.....	.....	.....	183	83	.....	155	40
14	.....	.....	.....	.....	.....	48	.....	176	38	.....	167	66
15	.....	.....	.....	.....	.....	78	.....	57	23	.....	281	72
16	.....	7	.....	.....	.....	16	.....	21	.....	.....	265	55
17	.....	9	.....	.....	.....	.....	.....	20	.....	.....	178	49
18	.....	8	.....	.....	.....	.....	.....	55	.....	.....	145	22
19	.....	21	.....	.....	.....	.....	.....	41	.....	.....	113	.....
20	.....	33	.....	.....	.....	.....	.....	29	.....	.....	88	.....
21	.....	56	.....	.....	.....	.....	.....	20	.....	188	76	.....
22	.....	72	.....	.....	.....	.....	.....	13	.....	422	56	.....
23	.....	72	.....	.....	.....	.....	.....	.....	.....	324	.....	.....
24	.....	62	.....	.....	.....	.....	.....	.....	.....	226	.....	.....
25	.....	52	.....	.....	.....	.....	.....	.....	.....	333	.....	.....
26	.....	73	.....	.....	.....	.....	.....	.....	.....	250	.....	.....
27	.....	68	.....	.....	.....	.....	.....	.....	.....	246	.....	.....
28	.....	74	.....	.....	39	.....	.....	.....	.....	281	.....	.....
29	.....	98	.....	.....	.....	.....	.....	.....	.....	426	.....	.....
30	.....	166	.....	.....	.....	.....	.....	.....	.....	398	.....	.....
31	.....	.....	.....	.....	.....	.....	.....	.....	.....	367	.....	.....

DAY.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1925-'26.												
1	.....	219	90	.....	.....	.....	.....	.....	24	51	.....	.....
2	.....	158	87	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	.....	130	90	.....	.....	.....	9	.....	.....	.....	.....	.....
4	.....	121	89	.....	.....	.....	90	.....	.....	.....	.....	.....
5	.....	101	76	.....	.....	.....	87	.....	.....	.....	.....	.....
6	.....	112	.....	.....	.....	.....	79	.....	.....	.....	.....	.....
7	.....	90	.....	.....	.....	.....	14	.....	.....	.....	.....	.....
8	.....	56	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	25	.....	.....
11	.....	.....	.....	.....	.....	.....	.....	.....	.....	286	.....	.....
12	.....	.....	.....	.....	.....	.....	.....	.....	.....	228	.....	.....
13	.....	.....	.....	.....	.....	.....	.....	.....	.....	390	.....	.....
14	.....	355	.....	.....	.....	.....	.....	.....	.....	344	.....	.....
15	.....	337	.....	.....	.....	.....	.....	96	.....	355	.....	.....
16	.....	301	.....	.....	.....	.....	.....	216	.....	251	.....	.....
17	.....	324	.....	.....	.....	.....	.....	283	.....	155	.....	.....
18	.....	319	.....	.....	.....	.....	.....	359	.....	94	.....	.....
19	.....	308	.....	.....	.....	.....	.....	337	135	65	.....	.....
20	.....	263	.....	.....	.....	.....	.....	302	310	48	.....	.....
21	.....	160	.....	.....	.....	.....	.....	265	114	36	.....	.....
22	85	170	.....	.....	.....	.....	.....	224	.....	28	.....	.....
23	79	183	.....	.....	.....	.....	.....	157	.....	21	.....	.....
24	69	181	.....	.....	.....	.....	.....	188	.....	15	.....	.....
25	66	180	.....	.....	.....	.....	.....	91	.....	.....	.....	.....
26	86	154	.....	.....	.....	.....	.....	69	.....	.....	.....	.....
27	87	125	.....	.....	.....	.....	.....	50	.....	.....	.....	.....
28	93	112	.....	.....	.....	.....	.....	40	252	.....	.....	.....
29	76	108	.....	.....	.....	.....	.....	35	297	.....	.....	.....
30	139	98	.....	.....	.....	.....	.....	31	122	.....	.....	.....
31	140	.....	.....	.....	.....	.....	.....	40	.....	.....	.....	.....

MONTHLY DISCHARGE of Great Eastern canal near Hartland, Kan., 1924 to 1926.

MONTH.	Discharge in second-feet.		Run-off (total in acre-feet.)
	Maximum.	Mean.	
1924-'25.			
November 16-30	166	58.1	1,720
December 1-6	216	14.2	1,690
February 28	39	39.0	77
March 1-3, 14-16	142	73.0	867
May 11-22	191	75.5	1,790
June 12-15	118	65.5	519
July 5-11, 21-31	446	268	9,550
August 1-22	367	211	9,200
September 13-18	72	50.6	602
The period			26,000
1925-'26.			
October 22-31	140	92.0	1,820
November 1-3, 14-30	355	187	9,240
December 1-5	90	86.4	855
April 3-7	90	55.8	552
May 15-31	359	164	5,510
June 1, 19-21, 28-30	310	179	2,480
July 1, 10-24	390	150	4,740
The period			25,200

SOUTH SIDE DITCH.

Location. In section 15, township 25 south, range 37 west, about half a mile south of Hartland, in Kearny county, and approximately one-half mile downstream from head gate.

Records available. Irrigation seasons of 1920 to 1926.

Gage. Gurley automatic water-stage recorder on south bank 100 feet upstream from highway bridge across canal, prior to 1926. In the last week in February, 1926, the site was changed to a point 300 feet farther downstream, below a recently constructed waste gate.

Discharge measurements. Made from flume at gage.

Accuracy. Stage-discharge relation fairly permanent. Daily discharge ascertained by applying mean daily gage heights to rating curve. Records fair.

DISCHARGE MEASUREMENTS of South Side ditch, 1924-'26.

DATE.	Made by—	Gage height.	Discharge.
1925.			
Mar. 14	Verne W. Stambaugh	1.2	48.2
Apr. 4	do	.72	19.5
May 16	do	1.66	108
July 25	do	2.87	269
Aug. 1	Earl G. Johnson	1.77	158
Aug. 8	do	1.66	156
1926.			
Apr. 24	Verne W. Stambaugh	2.23	73.5
May 1	do	2.03	53.8
June 19	do	2.49	105
July 3	do	2.22	78.0
July 10	do	2.30	87.0

DAILY DISCHARGE, in second-feet, of South Side ditch near Hartland, Kan., 1924 to 1926.

DAY.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1924-'25.												
1		23									139	
2		21					29				129	
3		4					20				99	
4		6					18				82	
5		24								121	77	
6		31								234	70	
7		31							30	91	168	
8		32							112		160	
9		36						14	287		117	
10		44				40		10	22		98	
11		45				91		138			81	
12		36				96		142				
13		15				113		184				
14						23		162				
15								118				
16						66		100				
17						77		35				
18						74						
19						68						
20						65						
21						60				51		
22						51				268		
23						43				241		
24						35				109		
25						18				193		
26										223		
27										142		
28										144		
29	13									124		
30	24									195		
31	27									129		

DAY.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1925-'26.												
1								53		118		
2								47		95		
3								35		75		
4								31		68		
5								22		58		
6								19		55		
7								29		49		
8								29		34		
9	27							41		42		
10	56							57		65		
11	65							87		21		
12	64							84		19		
13	66							89		91		
14	76							90		70		
15	84							15	97	37		
16	89							9	189			
17	99							8	42			
18	97							8	34			
19	78							8	113			
20	74						52	7	166			
21	74						98	6	175			
22	77						118	5	62			
23	80						95	5				
24	82						69	4				
25	88						62	4				
26	33						104	4				
27							116	4	88			
28							87	2	228			
29							78	1	163			
30							65		123			
31												

MONTHLY DISCHARGE of South Side ditch near Hartland, Kan., 1924 to 1926.

MONTH.	Discharge in second-feet.		Run-off (total in acre-feet.)
	Maximum.	Mean.	
1924-'25.			
October 29-31	27	21.3	127
November 1-13	45	26.8	689
March 10-14, 16-25	113	61.3	1,820
April 2-4	29	22.3	133
May 9-17	184	100	1,790
June 7-10	287	113	893
July 5-7, 21-31	268	162	4,490
August 1-11	168	111	2,420
The period	.....	.....	12,400
1925-'26.			
October 9-26	99	72.7	2,590
April 20-30	118	85.8	1,870
May 1-29	90	27.7	1,590
June 15-22, 27-30	228	123	2,930
July 1-15	118	59.8	1,780
The period	.....	.....	10,800

AMAZON CANAL.

Location. In section 8, township 25 south, range 37 west, in Kearny county, about one mile downstream from head gate.

Records available. Irrigation seasons of 1920 to 1926.

Gage. Gurley automatic water-stage recorder, on north bank about 50 feet downstream from wagon bridge across canal.

Discharge measurements. Made from bridge.

Accuracy. Stage-discharge relation practically permanent. Rating curve well defined. Daily discharge ascertained by applying mean daily gage heights to rating curves. Records good.

DISCHARGE MEASUREMENTS of Amazon canal, 1924-'26.

DATE.	Made by—	Gage height.	Discharge.
1925.		Feet.	Sec.-ft.
Mar. 7	Verne W. Stambaugh	3.25	120
July 24	do	4.85	294
Aug. 1	Earl G. Johnson	3.47	142
Aug. 8	do	3.60	154
1926.			
Apr. 17	Verne W. Stambaugh	2.97	97.1
June 19	do	4.42	212

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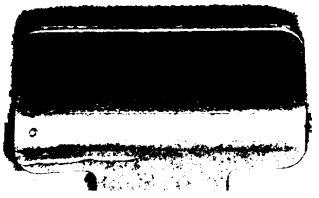
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